SOURCES, PATHWAYS AND SINKS OF LITTER WITHIN RIVERINE AND MARINE ENVIRONMENTS

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DECLARATION

This thesis has not been nor is being currently submitted for the award of any other degree or similar qualification.

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ABSTRACT

This research was developed as one of the first studies to investigate riverine litter problems. Baseline assessment methods were formulated to define the scope and nature of this pollution form. Assessments were carried out in three catchments; the Taff, East Lyn and Avill. The Taff was found to be atypical regarding the extent of the litter. In all catchments plastic sheeting formed the principal litter component.

The study also included an examination of the factors influencing the sources, pathways and sinks riverine litter pollution. These factors were drawn together through the development of a research model. Assessments of two quantifiable sources, sewage inputs through Storm Water Overflows (SWOs) and fly-tipping wastes, were undertaken. Greatest inputs of sewage-derived solids were introduced to the river through malfunctioning SWOs, the most numerous single component being sanitary towels. Whilst sewage-derived material constituted approximately 23% of all items on the River Taff, large quantities of waste, especially plastic sheeting, originated from fly-tipping sites.

Mobility of litter once introduced to the system was greatly dependent on river flow regimes. Some litter types, e.g. plastic sheeting, were more mobile than others and tended, after floods, to be stranded on vegetation.

Due to its high profile within the catchments and expected longevity, plastic sheeting was chosen for river-bank degradation trials. Results indicated that photodegradation occurred within samples, but only in the initial exposure period and that any further breakdown was likely to result from physical abrasion.

Marine areas were considered to be potential sinks for riverine litter, especially its more mobile components. An alternative sink for certain litter types such as cloth might be incorporation into the river-bank due to an ability to aggregate soil/sediment particles.

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CHAPTER 1

INTRODUCTION

The aesthetic quality of many river embankments is all too often marred by the presence of unsightly litter. Such aesthetic pollutants have been shown to significantly affect public perception of river (House & Sangster, 1991). Therefore, regardless of improvements in river water quality, brought about by stricter consent measures and increased investment, once a litter problem exists, not only will the public view the area less positively, but the adage "waste attracts more waste" may also follow.

The implications of riverine litter are not just limited to aesthetic degradation. Bankside litter is likely to constitute a significant threat to wildlife (Laist, 1987) due to the possibility of entanglement, and is also potentially hazardous to man if riverine areas are used recreationally.

Until recently, public pressure and media coverage have been predominantly directed towards urban and beach litter. Attitudes, however, have now broadened to encompass litter problems in both rivers and canals, the result of which has been an upsurge in preventative initiatives.

Northumbria and Welsh National Rivers Authority (NRA) regions have both taken decisive action to address litter within their areas. Northumbria took a multifaceted approach, combining litter picks with monitoring projects aimed at schools, whilst the Welsh region concentrated on research to gain a better understanding of the litter problem on rivers (The Water Guardians, 1992). Both were successful and acted as catalysts for further work.

Within Wales, the Keep Wales Tidy Campaign launched an initiative to tackle litter on the River Taff. As well as providing logistical insight into the feasibility of large-scale clearances, the work also highlighted some fundamental problems surrounding the river litter issue (Keep Wales Tidy Campaign, 1992). A considerable problem was felt to be the difficulties inherent in determining which bodies were responsible for tackling riverine litter. Although riparian owners are accountable for their river banks, in many cases records are so fragmented that ownership is impossible to prove. When land is known to be in private ownership, local authorities can take action against the owner if the land is considered to lower the neighbourhood amenity. Owners are then accountable for organising suitable clean-up measures. In areas of public access which are open to the air, principal litter authorities have the power to take appropriate action and enforce cleanliness standards, and the NRA only becomes responsible in cases where litter constitutes a flood risk. In light of these complex accountabilities, and lack of a single body to address the problem, the only way forward has been for co-ordinated efforts between water companies, councils and the NRA (SW Echo, 1991).

Increasing awareness regarding aesthetic pollutants such, as litter, has been reflected in recent proposals for a revised water quality classification scheme. In the 1970s River Quality Objectives (RQOs) were introduced as an informal means of setting goals for local water quality. The objectives provided a framework on which to base discharge consents, and have acted as a platform for river management to date. In recent years, considerable investments (£30 billion in the UK) channelled towards water quality improvements have resulted in the need to review RQOs so they may reflect new higher standards. In this context the Department of Environment (DoE) and Welsh Office (1992) has proposed the introduction of new Statutory Water Quality Objectives (SWQOs) to reflect new requirements and assessment methods. SWQOs will enable the Secretary of State to serve notice to the NRA regarding quality classes for river stretches.

In addition to SWQOs, there is a need for the collection of overall quality data which allow temporal variation to be measured. These are called General Quality Assessments (GQAs). For rivers, it is intended that GQAs will not only involve standard chemical and biological measures, but also nutrient and aesthetic classifications. The aesthetic classification will reflect general water quality and will deal for the first time with despoilation by litter. At present, assessment methods are still under trial and need to be properly validated before the next River Quality Surveys in 1995.

The inclusion of aesthetic classification for rivers in the new River Quality Surveys has underlined the need for innovative research in the realm of aesthetic pollutants such as litter, both for rivers (Williams et al, 1986) and for beaches (Williams et al 1993a). Although concern has risen regarding riverine litter (Western Mail, 1991), methods by which to measure the problem have as yet been limited to small-scale trial studies, with Davies' (1989) work forming the first bench-mark study. The research conducted in this present study is aimed at producing a more in-depth investigation of the riverine litter problem; not only to provide a scientifically rigorous baseline assessment method, but also to provide a better understanding of the processes governing sources, pathways and sinks of litter. It specifically addresses riverine litter problems, and as such marine litter is only examined in reference to this. Marine litter has been subject to much attention and research over the last twenty years, but little work has been carried out to determine links between freshwater sources and marine sinks. It is in this context only that the research is extended to cover the river/beach interface.

There are many potential sources of riverine litter, from bankside tipping and diffuse inputs to sewage inputs from Storm Water Overflows (SWOs) and untreated discharges. All are difficult to pin-point, and even harder to control. Further difficulties in tackling the problem arise due to the mobile nature of litter. Once deposited within a catchment, litter may be rapidly transported away from its point of origin and become distributed throughout the catchment, thus increasing the scope of the problem. Due to the dynamic nature of this system, no single method is capable of assessing the extent of the problem, and providing an understanding of the complex processes involved. A baseline survey may be implemented to determine the litter present at one point in time, but it will give no indication of any potential accumulation of material or long-term deposition. As such this research takes a broad-base approach and attempts to understand litter processes as well as devising appropriate baseline survey techniques.

Initially, a pilot survey assessment method was devised, in the form of a riverine-specific checklist. This was piloted on a small scale on the River Cynon - a major tributary of the River Taff (S. Wales). The pilot survey enabled essential adjustments to be made to the sampling design and checklist, before it was applied on a larger area. The modified method was then applied to three catchments - the Taff, E. Lyn and Avill, representing a spectrum of urbanisation. Assessments of the Taff, E. Lyn and Avill not only allowed comparisons to be drawn, but also enabled methodological validation in contrasting areas. In addition to this, other objectives are formulated to address litter sources, temporal variations, movement patterns, stranding mechanisms and ultimate fates.

(a) To collate available information on known inputs of debris into study areas, e.g. Storm Water Overflows, point sources of litter.

(b) To expand and consolidate the litter data-base already collected for the River Taff (Davies, 1989) by updating the checklist and applying new methods within the Taff catchment.

(c) To determine, for the purpose of method refinement, whether qualitative data will give adequate results to formulate hypotheses, or if quantitative data is necessary for this purpose.

(d) To evaluate the extent to which riverine litter is a localised problem in S. Wales due to high density linear urban developments along the lengths of the rivers, by comparison with less extensively urbanised catchments in the Bristol Channel.

(e) To gain an understanding of temporal variations in debris occurrence and distribution using bank clearance techniques.

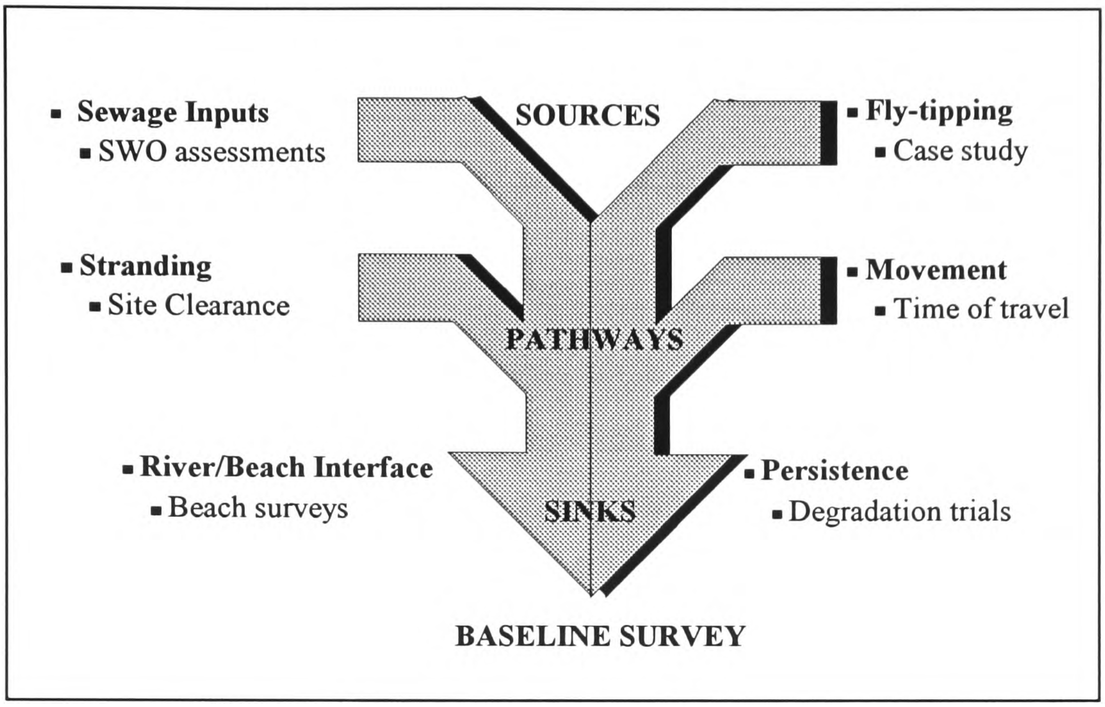
(f) To determine mechanisms of debris movement and patterns of stranding along river systems. For example, to establish whether movement occurs only in flood conditions or whether some movement occurs under dry weather flow and do certain litter items tend to be stranded at certain positions on river banks.

(g) To evaluate the contribution of fly-tipping to the riverine litter problem.

(h) To ascertain the proportion of beach litter which has originated from marine and riverine sources.

The broad nature of this work necessitated the development of a basic research model (Fig. 1.1). The model demonstrates the importance of gaining information on litter sources, pathways and sinks in order to realistically interpret baseline results. Under each heading (Fig. 1.1), appropriate studies were devised to gain the necessary information to produce a more detailed model of riverine litter processes.

Figure 1.1. Basic Riverine Litter Research Model



This research constitutes one of the first pieces of work in the field of riverine litter. As such emphasis is placed on the development of scientifically sound methodologies on which further work may be based.

CHAPTER 2

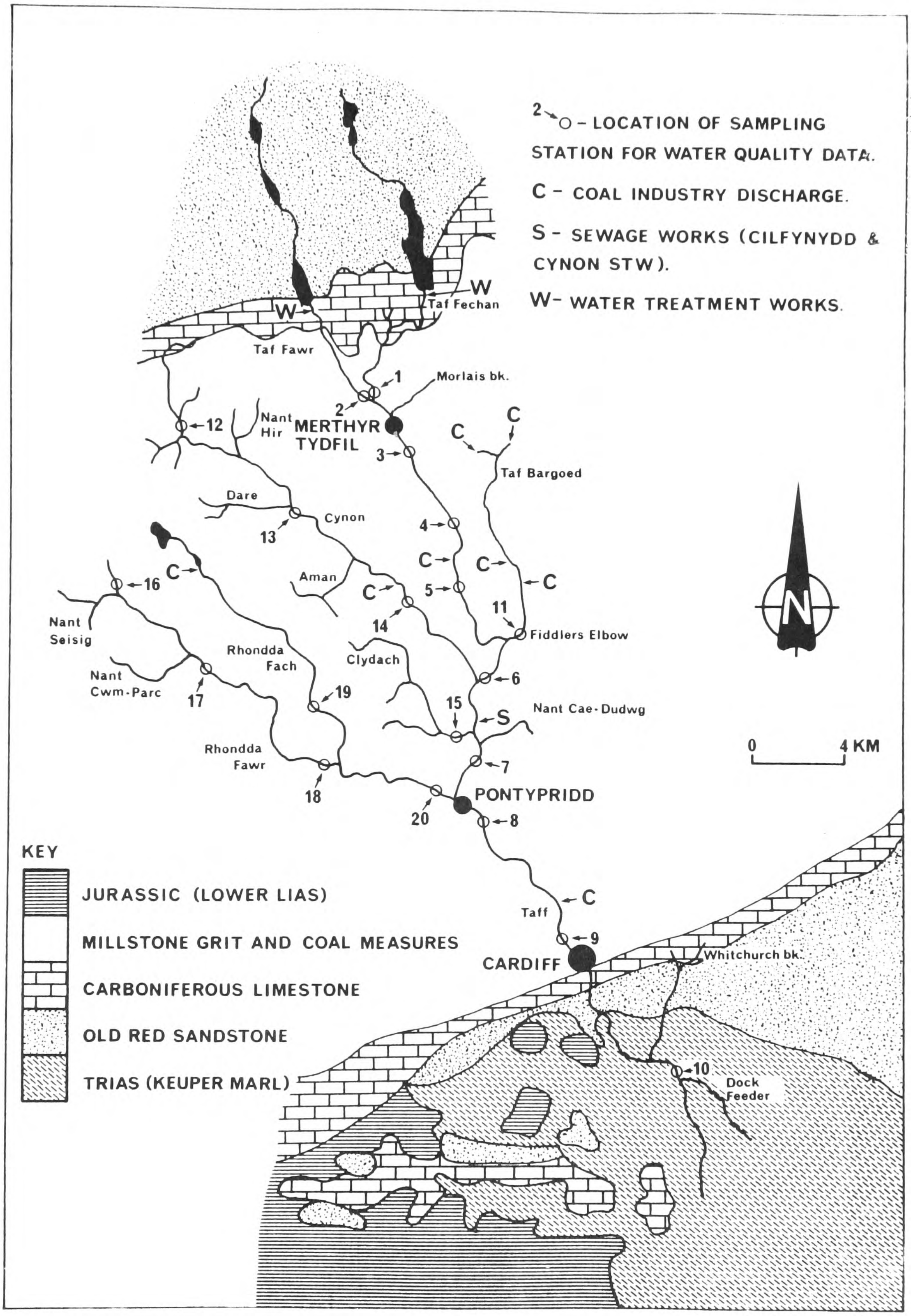
PHYSICAL BACKGROUND

The Taff Catchment

Until the early 18^{th} century, Taff Vale was a largely unspoiled and peaceful backwater famous for the quality of its salmon fishing. This soon changed when exploitation of the South Wales Coal fields for their natural resources (limestone, iron and coal) resulted in inevitable pollution of its major river system, the River Taff. In the 19^{th} century, Merthyr Tydfil underwent a period of explosive growth as a result of its iron works. "The effluent from these works poured into the River Taff near its headwaters with serious consequences for the whole of the main river" (Williams, 1984, p1). The Taff catchment also became one of the most intensively mined areas in the UK resulting in a legacy of spoil tips whose surface run-off still pose problems today. Rapid population growth during the 18^{th} and 19^{th} centuries in the Taff catchment resulting from these expanding industries led to the predominantly urbanised and industrialised catchment (490 km^2) now characteristic of this S. Wales area. In parallel with the problems of an expanding population came serious sewage contamination below dense population centres.

The outcome of all these factors was that the Taff "became one of the most polluted (rivers) in the country, fishless for most of its length and flowing with the filth and waste of the people and industry crowded along its banks" (Williams, 1984, p1). In recent years, however, with the industrial decline, improvements in sewage treatment

Figure 2.1. Taff Catchment Geology, Location of Sampling Stations and Major Discharges



and stricter effluent constraints, a gradual recovery of the Taff has been noted (Williams, 1984; Williams & Brooker, 1985). The NRA, together with Welsh Water, industry and other organisations, continue to encourage this recovery and aim towards eventual restoration of the river.

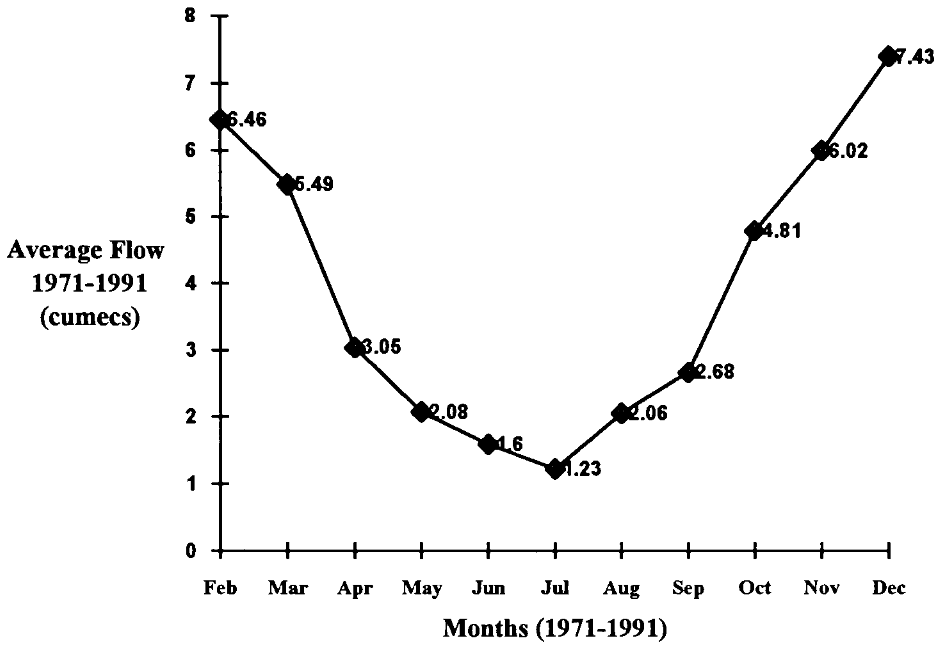
Physical

The Taff rises from the Brecon Beacons' Old Red Sandstone escarpment, and flows 57 km to join the Severn Estuary at Cardiff (Fig. 2.1). Its two upland rivers, the Taf Fawr and Taf Fechan, have been partially impounded to form reservoirs for public water supply, before flowing 16 km through Carboniferous Limestone and Millstone Grit to their confluence above Merthyr Tydfil (Thomas et al, 1986). The main river flows in a south-easterly direction downstream from Merthyr Tydfil through outcropping Coal Measures and then overlaying Pennant Sandstone. Four major tributaries representing 56% of the catchment join the river during its course through the South Wales coal field; the Taff Bargoed, Cynon, Nant Clydach, and Rhondda (Fig. 2.1). Downstream of the Rhondda's confluence at Pontypridd, a deep gorge has formed in Carboniferous Limestone at Taffs Well, through which the river passes before entering the Cardiff Plain and eventually discharging into the Severn Estuary. The Taff's tidal limit is at Blackweir, Cardiff (Bent et al, 1985).

The Taff, along with most of the S. Wales coal field rivers, is very steep, dropping approximately 11 m in every 1 km. This results in a turbulent river, causing bed and bank erosion. The mountainous catchment, with heavily developed banks (land directly adjacent to the river is often impermeable due to coverings such as concrete), causes rapid run-off and a shortening of the time between the onset of rainfall and water reaching the river. In an area renowned for its rainfall, ranging from 950 mm per annum in Cardiff to 2400 mm in Brecon Beacons, this characteristic of the Taff Basin results in a very "flashy" river. Flow data collected for the River Cynon (NRA, Welsh

Region) over a twenty year period, indicates average annual fluctuations of between 1.2 and 8.0 cumecs (Fig. 2.2).

Figure 2.2. River Cynon: Average Monthly Flow Data 1971-1991



Sewage Treatment

Three small sewage works serve the headwaters of the R. Taff. Upper and middle catchment treatment takes place at two large works, Cynon (ST 0825 9295) Sewage Treatment Works (STW), an activated sludge plant serving a population of approx. 75,000, and Cilfynydd STW (ST 0840 9290), a biological filtration plant serving a population of approx. 65,000 (Fig. 2.1). Sewage from the Rhondda valley and catchment below Pontypridd, is transported to a crude outfall in the Severn Estuary via the Ystradfodwg and Pontypridd trunk sewer. Due to the combined nature of the sewage system, both surface water and sewage are transported together for appropriate treatment and disposal. The high rainfall in S. Wales exacerbates the flow fluctuation problems inherent in this system. To cope with periods of high flow, Storm Water Overflows (SWOs) act as release valves along the length of the system, generally releasing untreated effluent direct to the river. Storm Water Overflows are numerous in the Taff catchment, and as most (almost 100 %) are unscreened, their potential impact is great. Sewage treatment hardly existed in the 19th century, raw sewage being described by Mawle et al (1985) as one of the main pollutants of that time, together with industrial inputs. Although in recent years, improvements have been made in both these areas, the characteristic linear urban development of S. Wales' catchments makes significant advances in reducing sewage contamination difficult.

Ecology

The accelerated development which has taken place in the Taff Basin in the last two hundred years has led to considerable ecological stress. "Prior to this the basin would have contained stretches of broad-leaved woodland habitat in a predominantly rural area" (Keep Wales Tidy Campaign, 1992, p8). Increased industrialisation initiated the degradation of habitats, and more recently modifications have occurred as a result of flood defence schemes. Where stretches of river have been embanked, vegetation characteristic of disturbed ground develop, e.g. young scrubby trees and poor cover. Areas of the Taff that have undergone little or no bank management/flood defence work offer high value wildlife habitats, dense with tree and plant species. Potential also exists for other scrub areas to succeed into more mature habitats of greater botanical importance.

A common plant species found on the River Taff's banks, is Japanese Knotweed (Reynoutria japonica). So effective has the colonisation of this species been, that since its introduction to the UK in 1825, the species has become a pest in many areas of S. Wales. Along some stretches of the Taff, Knotweed density has caused the vegetation to become monospecific. In this case not only is diversity lost, but also vegetation cover, in periods outside the Knotweeds' growing season (August - October). "One of the most important functions of the riparian vegetation lies in the provision of cover for wildlife" (Keep Wales Tidy Campaign, 1992, p11). The Taff's water quality is sufficient to support mallards, teal, mink, kingfisher and heron, all of which may be found in bankside grasses and low hanging vegetation. The continued provision of this cover is of extreme importance if small mammals such as otter are to be encouraged.

Water Quality

Poor water quality was a problem in the Taff catchment even prior to the twentieth century. "Pollution control, like sewage treatment, was virtually non-existent and deteriorating water quality was the inevitable consequence of the industrial and urban development of the Taff system in the 19th century. In 1860, the main pollutants were thought to be suspended solids from the coal and iron industries, 'mineral waters' from the coal mines, lime and vitriol from tin-plating works and raw sewage from the expanding population within the catchment" (Mawle et al, 1985, p38).

Williams and Brooker (1985) have documented improvements in water quality of the Taff catchment in recent years. The closure of some of the industrial contributors of river pollution, together with stricter consenting on the remaining inputs have succeeded in bringing about some of these improvements.

Thomas et al (1986, p4) described aspects of water quality from a multi-disciplinary study aimed at "identifying areas where stable fish populations might be expected and areas where variable water quality jeopardises the long-term prospects for the fishery". A common water quality measure, used by Thomas et al (1986), is the National Water Council's (NWC, 1977) classification system. This categorises river water quality into one of five groups; 1a Good Quality, 1b Lesser Good Quality, 2 Fair Quality, 3 Poor

Quality and 4 Bad Quality, based on values of specific water quality determinands. Analysis of the Taff's upper and middle reaches, down to the Fiddlers Elbow (35 km), indicated generally good water quality (NWC Class 1B-2; Fig. 2.1). More variable results for the river below this point led to a reduction in NWC classification, e.g. Cilfynydd, Class 2-3. Significantly variable BOD and NH_3-N concentrations, in the main river below Abercynon and the lower reaches of the Cynon and Rhondda tributaries, reflected the extensive use of the catchment for domestic and industrial effluent disposal. Thomas et al (1986) considered the suspended solids recordings throughout the catchment, to be "satisfactory" (Table 2.1). However, with solids transport being strongly related to storm events (short in duration), such episodes are likely to have passed unrecorded. Considering this, the true overall picture is likely to be somewhat unsatisfactory.

Table 2.1. Water Quality within the Taff Catchment

Sampling Sites	Grid Reference	Ammonia (mg/l)	Suspended Solids (mg/l)	BOD (mg/l)
T. Fawr	SO 001 150	0.21	23.2	4.6
T. Fechan	SO 037 076	0.06	27.4	4.5
Rhydycar	SO 049 056	0.12	40.3	6.0
Troedyrhiw	SO 068 024	0.08	17.6	5.7
Merthyr Vale	SO 073 999	0.05	43.2	4.3
Abercynon	SO 084 947	0.18	149.0	4.8
Cilfynydd	SO 084 916	1.48	75.73	7.8
Pontypridd	SO 073 898	0.93	104.1	6.1
Taffs Well	SO 124 831	0.78	82.5	7.0
Black Weir	ST 171 181	0.77	80.7	8.5

(Source: Thomas et al, 1986)

Solids loadings surveyed below coal sites, highlighted three colliery complexes as significantly impairing water quality (Merthyr Vale, Deep Navigation/Trelewis/Taff Merthyr and Lady Windsor). "The assessment of coal site impact is complicated by the importance of antecedent and contemporaneous weather conditions, the nature of operational activities, coal washing, product transport arrangements, treatment facilities, waste disposal, and the site location, area and management" (Thomas et al, 1986, p15). Discharges from Leiners plc, drainage from Treforest Industrial Estate and BSC Dowlais effluent were all confirmed, through toxicity tests, to be potentially harmful to the watercourse (Thomas et al, 1986). Since Thomas et al's (1986) work, mine and factory closures have resulted in water quality improvements. To date however, these changes have not been discussed in published work.

The Avill Catchment

Physical

The entire Avill catchment (53 km^2) lies within the Exmoor National Park, which at its highest point, Dunkery Beacon, rises to 519 m OD (Fig. 2.3). Much of Croyden Hill, the west end of the Brendons and the south-eastern slopes of Dunkery, drain to form the complex headwaters of the Avill. These headwaters and steep-sided valleys overlie slate and silt stones of the middle Devonian. The river's two major tributaries, Timberscombe and Wooton Courtney streams join the Avill between Bickham and Knowle and flow over Permian and Triassic deposits (Fig. 2.3). After passing through Cowbridge, the Avill continues beneath the long wooded ridge of Grabbit Hill, reaching Dunster through the castle grounds beyond Gallox Bridge. Flowing around the east side of the castle grounds, which guards the entrance of the Avill valley, the river reaches Loxhole Bridge on the A39. The average gradient of the main river from source to Loxhole Bridge is 1:36. In 1964 a flood discharge channel was constructed at this point to carry surplus water off to sea. The channel is approximately 1.5 km long with concrete sides and bottom, serving to move excess water rapidly to sea at the eastern edge of Dunster Beach. Comprehensive land drainage schemes that followed the construction of this flood alleviation channel effectively resulted in Dunster Marsh's destruction. Additional drainage work carried out in the 1960s, involved radical straightening of the old River Avill's course, resulting in its passage to sea via a separate outfall one kilometre to the west.

Regular gauging results (NRA, Wessex Region) indicated the river's average flow to be 0.76 cumecs. Six significant abstraction licences have been granted for spray irrigation, four of which are in the Dunster Marsh area. Although the flood defence channel is not categorised as an abstraction, it does in fact remove substantial quantities of water from the river's natural channel and lower reaches.

The Avill catchment is largely rural, with only one town, Dunster, along its length. Principal income for the region results from farming and tourism, the latter resulting in major population fluctuations within the catchment during the summer (10,000 - 40,000). Although general litter contamination of the Avill is not prominent during summer months, the increase in population does inflict excessive demands on the catchment's sewage disposal system. As the primary sewage disposal route is to sea, effects of such increased loadings may not necessarily be restricted to the locality.

Sewage Treatment

In the upper catchment where little urbanisation is present, private septic tanks are the main form of sewage treatment. Downstream, at Cutcombe, Wheddon Cross and Timberscombe, where the area is more densely populated, sewage is transported to a central treatment works at Minehead (SS 9945 4698). Until 1988, sewage was disposed via a short sea outfall with no screening. Recent investments at Minehead now means that sewage is screened (25 mm to 5 mm 'D' screen), disinfected, and discharged to sea via a long sea outfall 700 m below the high water mark (SS 9970 4700). Future plans include possible primary and biological treatment facilities. The only other significant outfall in the vicinity is at Watchet (ST 0673 4425), which discharges unscreened sewage to sea 135 m below mean low water. Primary treatment is also planned for this outfall in the future.

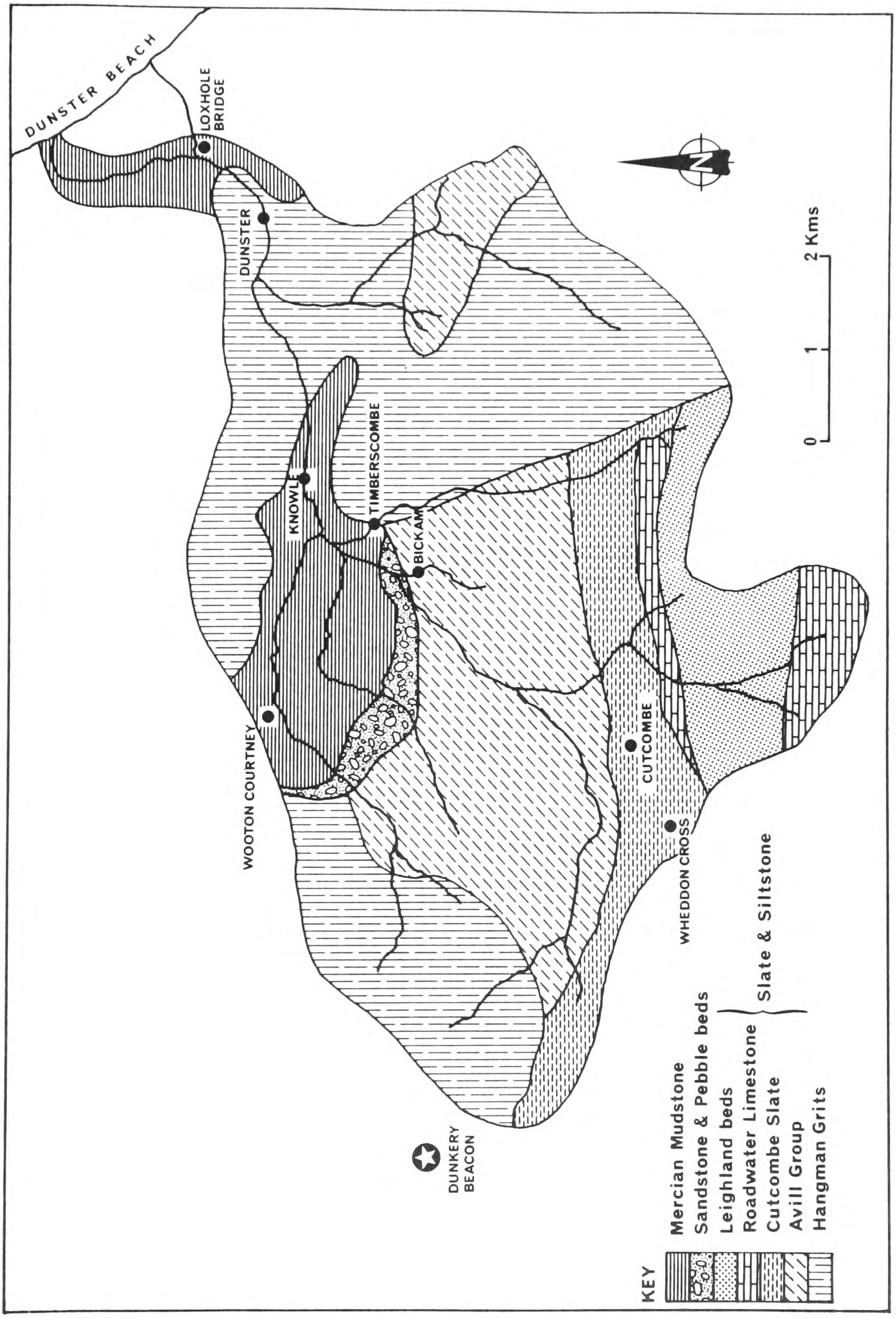
Ecology

Literature on the Avill's ecology is sparse. The NRA has undertaken a river corridor survey of the Avill's lower reaches, from Marsh Street Bridge (SS 994 444) to Dunster Beach outfall (SS 994 454; McFadzean, 1992). This reach was chosen for study because of the introduction of more varied characteristics resulting from channel improvement schemes. Upstream of this section, the river is predominantly pasture land.

Adjacent habitats of the downstream reach consist of improved permanent pasture used for intensive dairying, and short lengths of woodland and reed-bed. Nettle (*Urtica dioica*) and Hemlock (*Conium maculatum*) constitute the primary bankside vegetation, interspersed with scrub pockets. Channel habitat variety has been limited as a consequence of the straightening works and because abrasive flood flows no longer scour the channel.

Future enhancement of this section of the Avill has been suggested through revitalisation of some of the old river course by redirecting water to provide a wetland. Implementation of this scheme relies on successful negotiations with the present land owner, and looks unlikely at the present time (1993). Other more minor opportunities lie in tree planting schemes along the channel margins, and encouragement of flora diversification.

Figure 2.3. Avill Catchment Geology



Water Quality

Water quality within the Avill catchment is generally within class 1a of the NWC classification system (Table 2.2). This is not surprising considering there are no discharges of treated effluent within the catchment. Occasional pollution incidents have been known to occur, for instance as a result of farm slurry inputs. Fortunately, long-term consequences of such spillages have been minimised due to the river's overall high oxygen levels

Table 2.2. Water Quality within the Avill Catchment

Sampling Sites	Grid Reference	Ammonia (mg/l)	Suspended Solids (mg/l)	BOD (mg/l)
Hawkwell 2	SS 929 398	< 0.02	25	6
Timberscombe	SS 953 421	0.11	24.8	1.9
Hawkwell 1	SS 924 397	0.37	4.9	1.1
Avill Marsh	SS 995 455	0.03	12.96	1.66

(Source: NRA Wessex Water Archive System)

The overall water quality of the River Avill is excellent and, with no significant pollution problems, the "NRA's involvement in maintaining the river is consequently low key with the main focus of attention the inlet and outlet structures" (McFadzean, 1992, p1).

The East Lyn Catchment

Physical

The Lyn catchment (76 km^2), a predominantly rural region, encompasses areas of both North Devon and Somerset and lies entirely within Exmoor National Park. The only towns along its passage are the coastal resorts of Lynton and Lynmouth; originally small market towns, which have since developed into tourist resorts with both Exmoor National Park and dramatic coastal scenery as attractions.

The Lyn rises from the northern part of Exmoor, which lies at over 305 m OD. This considerable height above sea level results in the characteristic steep-sided valleys found throughout the moor. Figure 2.4 illustrates the area's comparatively simple geology, showing the Carboniferous Culm Measures and Devonian Beds characteristic of the N. Devon and Somerset coastline. Both Carboniferous and Devonian age rocks consist of alternating slate, shale and sandstone beds with occasional interbedded Limestone and Grits (Broome, pers comm). Exmoor and the Lyn catchment lie on lower Devonian Beds. Resultant soil types vary from deep brown earths, characteristic of south facing slopes, to podsols in higher areas, with heavy rainfall and considerable leaching.

The East Lyn flows a total of 15.9 km from its headwaters on Exmoor to the tidal limit 1 km downstream of Lyn Bridge (SS 7198 4854). Weir and Chalk Waters, join at Oare Water proceeding to Malmsmead, below which they converge with Badgworthy Water forming the East Lyn river (Fig. 2.5). The East Lyn then passes towards the village of Brendon through a narrow grassland valley. Beyond, towards Watersmeet, large boulders become a characteristic of the bed as the river enters a valley with almost sheer sides. Waters from Farely and Hoaroak join the East Lyn at Watersmeet after the passage over two large falls. Below Watersmeet the river then travels in a westerly direction towards Middleham, at the outskirts of Lynmouth. Here the river widens considerably, and the large boulders become a less prominent feature. After joining the West Lyn at Lynmouth, the river completes its journey to sea via Lynmouth's small tidal harbour.

Rainfall varies considerably throughout the Lyn catchment; from 1780 mm on the highlands, to 1270 mm in the lower catchment. The high rainfall in combination with the steep-sided nature of valley, results in greatly fluctuating flows. The Lyn's 'flashy' nature led to its infamy in 1952, when a flood destroyed a large part of Lynmouth's roads, bridges and buildings, and took the lives of 28 people (Allen, 1978).

Sewage Treatment

Sewage treatment within the Lyn Catchment is very limited. Many farm houses in the river's upper reaches do not connect into the public sewer, but instead have their own septic tanks. Those tanks which were in operation before 1989 have not been registered, and are therefore not consented discharges. As such, the impact of these effluents goes unmonitored, and their existence unlikely to be discovered unless complaints lead to investigation by the NRA. The exact number of such discharges is therefore at present unknown.

Brendon, is the sole treatment works in the catchment, and merely consists of a septic tank screened by 6 mm COPASACs. This constitutes one of only two consented Storm Water Overflows (monitored by the NRA) in the catchment, discharging to the river below Brendon (SS 7639 4796; Fig. 2.5). The one remaining consented storm sewage overflow, is situated in Lynmouth at Rock House (SS 7229 4962) which spills straight into Lynmouth Bay and the Bristol Channel. Another outfall in the area is at Foreland Point lighthouse (Fig. 2.5). This discharges crude sewage into the Channel.

The sea outfall at Lynmouth is a means of sewage disposal for the entire Lynmouth/Lynton population. With the influx of tourists during the summer season the population can increase considerably. In 1989, the winter population of 1,790 rose to 4,370 in the summer period. It has been predicted that these figures will increase to 1,950 and 4,530 respectively by the year 2001 (Brecken, pers comm). Therefore, at present, a substantial amount of crude sewage is being discharged untreated from this source. In addition to reducing the water quality to a level which falls below the EC Bathing Water Directive (European Community, 1976) standards, "sanitary towels, condoms, and panty liners, too frequently litter the popular holiday beaches" (Devon Environment News, 1992, p4).

A sewage treatment improvement programme has been initiated in the Lyn area. Plans include a new treatment works to serve Lynton and Lynmouth which should be operational by 1994. Sewage treatment from this area will then undergo secondary/tertiary treatment and will be screened to 6 mm standards

Ecology

Ecological monitoring has only recently been introduced to routine river assessments for the S.W. Region NRA. As such, no formal documentation of results exists to date, although raw data for recent years was available. During 1990 and 1991, six reaches underwent river corridor surveillance within the E. Lyn catchment.

Large catchment areas consisted of improved grassland and scrub, with some of the tributaries, such as Farely Water, having mixed deciduous woodland, primarily Oak. Most of the banks were natural, the main exception being Lynmouth, where the river passed through a man-made concrete channel to sea.

Typical bird species associated with the river are dippers and grey wagtails, but kingfishers are uncommon due to the lack of suitable feeding sites. Otters use the Lyn extensively, and mink may also be present, though not in problematical numbers.

Water Quality

South West NRA routinely samples four sites within the E. Lyn catchment, usually on a monthly basis (Fig. 2.5). Water samples are analysed for a range of chemical and physical parameters or determinands, only some of which are used for NWC classification.

Figure 2.4. East Lyn Solid Geology

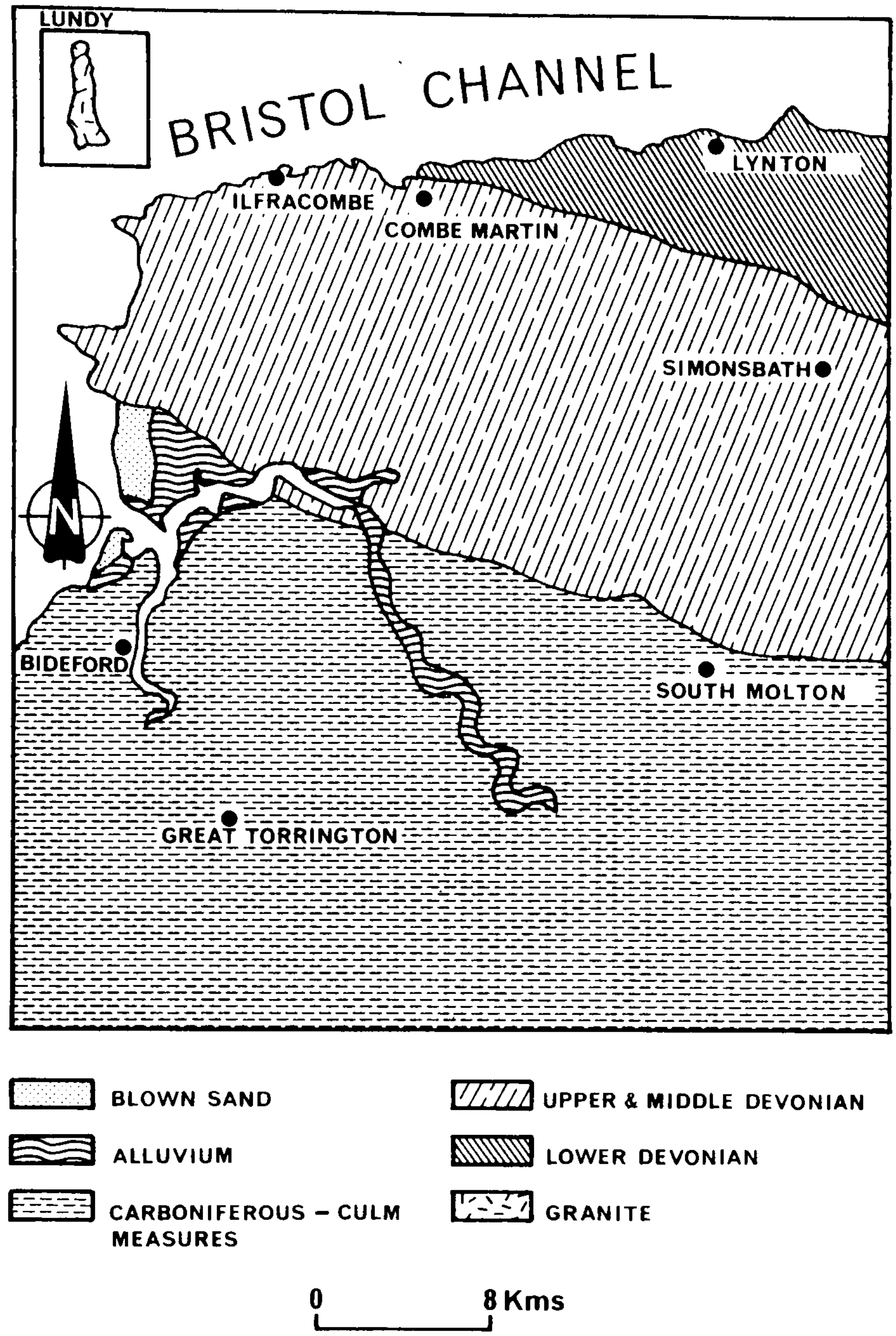
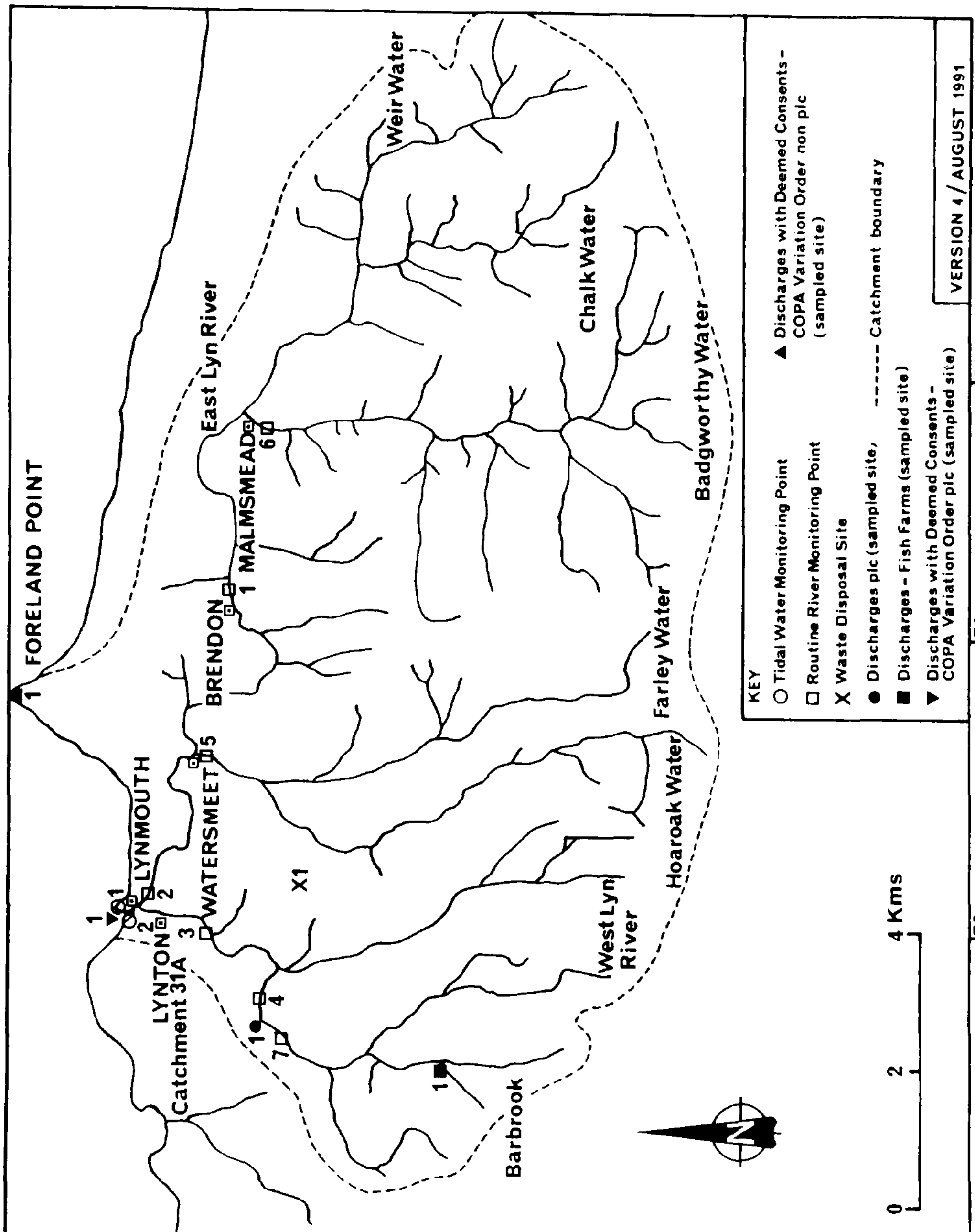


Figure 2.5. Lyn Catchment



Source: NRA Catchment Action Plan: West & East Lyn Rivers.

Table 2.3. Water Quality within the East Lyn Catchment

Sampling Sites	Grid Reference	Ammonia 95%ile	Suspended Solids 95%ile	BOD 95%ile	NWC Class
Leeford	SS 7697 4829	0.040	2.4	4.7	1b
Lynmouth	SS 7240 4946	0.034	2.2	1.9	1a
Watersmeet	SS 7435 4854	0.040	2.4	2.0	1a
Malmsmead	SS 7918 4770	0.043	2.9	2.2	1a

(95%ile - Maximum limits met for at least 95% of the time)
(Source: Milford, 1992)

In recent years the East Lyn's water quality record has been excellent (Table 2.3). Absence of urban or industrial pollutant sources have ensured good water quality, the main threat being from agriculture-related pollutants. Documentation of the catchment's NWC classifications since 1985 indicated that no ratings in excess of 2 were recorded (Milford, 1992). This "fair quality" (2) classification was given to Leeford twice during the 1985-1991 monitoring period. Leeford has demonstrated a decline in overall water quality from a 1a rating during 1985-87, to alternating 1b and 2 classifications for the period 1988-1991 (Milford, 1992). High BOD values have been indicated as responsible for the decline in water quality. Low flows and problems from extractions and septic tank discharges were considered responsible for the evaluated BOD levels during this period (Broome, pers comm). Lynmouth water quality samples showed a constant 1a rating, whilst those for Watersmeet and Malmsmead showed improvements from 1b to 1a during the seven year monitoring period.

In 1978, the NRA S.W. Region assigned River Quality Objectives (RQO) to all river reaches routinely monitored, and those subject to effluent discharges. Long-term objectives were established with a view to maintaining adequate quality to ensure the watercourse's future protection. RQOs of 1a classification were set for the entire Lyn catchment, and for the E. Lyn, only Leeford's excessive BOD values (exceeding the standard by 58%) resulted in non-compliance with the standards. The NRA will soon be releasing its own water quality classification scheme to supersede the NWC system. This will be implemented in time for the next national survey in 1995, and will be a more definitive assessment, minimising the need for interpretation, and hence lessening variations in regional approaches. South West NRA have achieved a high standard of water quality within the Lyn catchment and throughout their region by rigorous reviewing and monitoring of discharge consents. Future emphasis will be on pollution prevention through catchment management plans and action task forces. In parallel, considerable effort will be directed towards increasing public awareness on pollution problems with a view to preventing incidents through education of public attitudes.

CHAPTER 3

METHODOLOGICAL DEVELOPMENT AND PILOT STUDY

Methodological Context

Due to a research paucity in riverine litter assessment, no definitive methodology exists to act as a guideline for current/future work. Consequently, in the present research, survey design and methodology development were considered to be of paramount importance.

Surveys in associated research areas have been designed to fulfil a variety of objectives. These range from simple enumeration studies, giving quantitative and compositional results, to detailed monitoring of indicator items, providing insight into origins and ages of waste. Studies are often designed to gain basic data covering large geographical origins, or to collect detailed information on specific regions. Most are limited by time, in monitoring frequency or the total length for the survey. An important point all surveys must acknowledge is skill level of the end-user, and their expected data collection proficiency. Often a survey aimed at public participation will be targeted as much towards providing an educational package for participants as to providing a means of collecting data. In doing so they serve two equally valid functions.

The Coastwatch UK Marine Litter Survey is an example of a public participation survey (Appendix A1). It is targeted towards volunteer groups and aims to gather basic information from large geographical areas. In almost all cases riverine litter assessments have evolved from their more established marine counterparts. In parallel with Coastwatch UK, a riverine survey form was launched in 1991, named Riverwatch. Its user-friendly format is similar to that of Coastwatch, along with a large geographical target area. Riverwatch, however, aims to monitor all aspects of river pollution, of which only a small part relates to litter. Both surveys fulfil educational roles in raising the environmental awareness of the large number of volunteers who participate each year. Results are collected on an annual basis and cover large areas which would be logistically impossible without public participation. Unfortunately, a problem inherent with volunteer-based surveys is the questionable credibility of results. With no training, unskilled surveyors cannot guarantee any consistency in monitoring techniques. As such, results from this type of survey should be treated with caution.

Surveys targeted for use within the scientific community tend to be more rigorous in the sampling methodologies used and, the type of data collected. One of the first marine surveys of this nature was developed by Garber (1960). Garber (1960) attempted to quantify the appearance of receiving waters as an operational efficiency indicator of offshore treatment plants. This approach was later adapted for use as a shoreline survey (NRA, 1992). Garber's (1960) logsheet, was split into two sections (Appendix A2). Section A dealt with the presence and absence of certain visual characteristics which related to water quality: Section B dealt with material quantification at differing beach positions, and numbers and activities of beach/sea users. The survey format gave immediate assessment allowing rapid assimilation of valuable information on the recreational water quality of large areas. The main drawback of Garber's (1960) approach was its subjectiveness. For example, for water quality factors, only presence and absence were recorded in section A. This may be insufficient since, for example, the amount of material such as tar/floating matter may be important. However, even in section B, where material quantification was attempted, assessment was still subjective with the application of a scale ranging from absence of material to an amount which was sufficient to be objectionable. No guidelines or definitions were given relating to this scale.

Again, a riverine equivalent has been developed based on this marine survey. The National Rivers Authority (NRA) used facets of Garber's (1960) work for their Investigation of the River Taff Litter Problem (Davies, 1989). The river was primarily divided along its length into 2 km reaches. On a random ease of access basis, one 40 m site was selected within each reach, and a subjective qualitative assessment of litter, within the river channel and on both banks, was carried out using a scale adapted from Garber (1960). A five metre belt transect was then established and litter was quantified on a logarithmic scale. This study allowed for far more extensive site descriptions, and although still anecdotal in parts, the checklist did include litter categories more relevant to the riverine situation (Appendix A3). Unfortunately the litter types were not grouped, except for a division between sewage and other refuse. This method has since been applied to assess litter on two tributaries of the River Taff, namely the River Cynon and River Rhondda (Davies & Boden, 1991).

Another bench mark in marine litter assessments was devised by Dixon and Dixon (1981) for the Tidy Britain Group's (TBG) Marine Litter Research Programme (Appendix 4). This involved a more complex sampling regime, and required certain specialist knowledge for accurate item identification. The survey could be implemented in many ways; to gather nominal, ordinal or interval scale data, or to review the effectiveness of certain litter abatement legislation. Dixon and Dixon (1981) in their marine litter surveillance study, outlined the following method of beach litter assessment. Stratified random sampling was used to select beach survey sites. Within these survey sites, sampling areas were also selected via random number tables. Three, five-metre wide belt transects were used. They were at right angles to the sea, encompassed all high water marks and wind-blown litter, and extended an additional thirty metres down shore. Data on abundance, fabrication of materials, geographical origins, ages and original contents of containers were recorded within these transects. A checklist allowed data recording in predetermined categories, giving definitive results rather than anecdotal descriptions. This method has been widely accepted as a technique to study marine litter (Simmons & Williams, 1993) and has been further adapted to investigate specific problem areas.

Marine surveys have greatly influenced the formulation of riverine litter methodologies. Although obvious parallels do exist between approaches needed for both marine and riverine assessments, it is not sufficient to simply apply one to the other, due to physical differences within each environment.

Survey forms (The Yorkshire Rivers Litter Monitoring Project, 1991) developed by the National Rivers Authority (NRA) and the TBG for The Yorkshire Rivers Litter Monitoring Project (Appendix A4), hardly differed from those used for the TBG's Marine Litter Research Programme (Dixon & Dixon, 1981). Litter types were categorised primarily by composition i.e. metal, paper, plastic, with some additional arbitrary groupings. The benefits of this approach were negated by the "details of visit" section which requested anecdotal recordings such as description of sites and possible sources of litter. Such recordings result in data analysis limitations. Little consideration appears to have been given to the differences between marine and riverine litter. Emphasis was placed on the recording of container details, as in the marine surveys e.g. age and place of manufacture. Containers, however, appeared to be a far less prominent feature of riverine systems. More evident were household wastes such as furniture and decorating material due to the high incidence of fly-tipping. The omission of such categories and the lack of site background information meant considerable improvements were necessary in order that the data would allow relevant hypotheses to be formulated and tested.

The baseline survey designed in this research is intended to be a more realistic riverine counterpart to Dixon & Dixon's (1981) work. Emphasis was placed on developing a scientifically sound sampling regime together with more river-specific assessment methods. Facets of previous work were combined with new ideas to produce a non-anecdotal checklist format survey (Appendix A6).

Sampling Regime Development

Successful environmental sampling studies require detailed planning of the major tasks involved. In response to this, many statisticians and environmental scientists have provided guidelines to aid formulation of sound survey designs (Cochran, 1977; Gilbert, 1987; Ribic et al, 1992). Common to each approach is an emphasis on formulation of realistic objectives that must be stated and clearly understood before work can progress. In this initial pilot project, the objectives were to develop, implement and refine a survey that could eventually be applied on various river catchments to gain valuable baseline data for riverine litter. Due to the diversity of previous work in this general area, ***no*** precedent exists regarding the optimum type of data, i.e. qualitative or quantitative. As such, a principal aim of the pilot study was to determine merits of each data type and their respective statistical analysis techniques. If qualitative data was considered to yield sufficient results, this data format would be used in the main survey. In the pilot study, however, both data types were collected.

The River Cynon, a tributary of the River Taff, was chosen for the pilot study work (Fig. 3.1). The Cynon's close proximity to the Taff and small size (22 km) enabled a detailed knowledge of the area and litter processes to be gained. This critical insight was channelled towards the development of a suitable sampling programme.

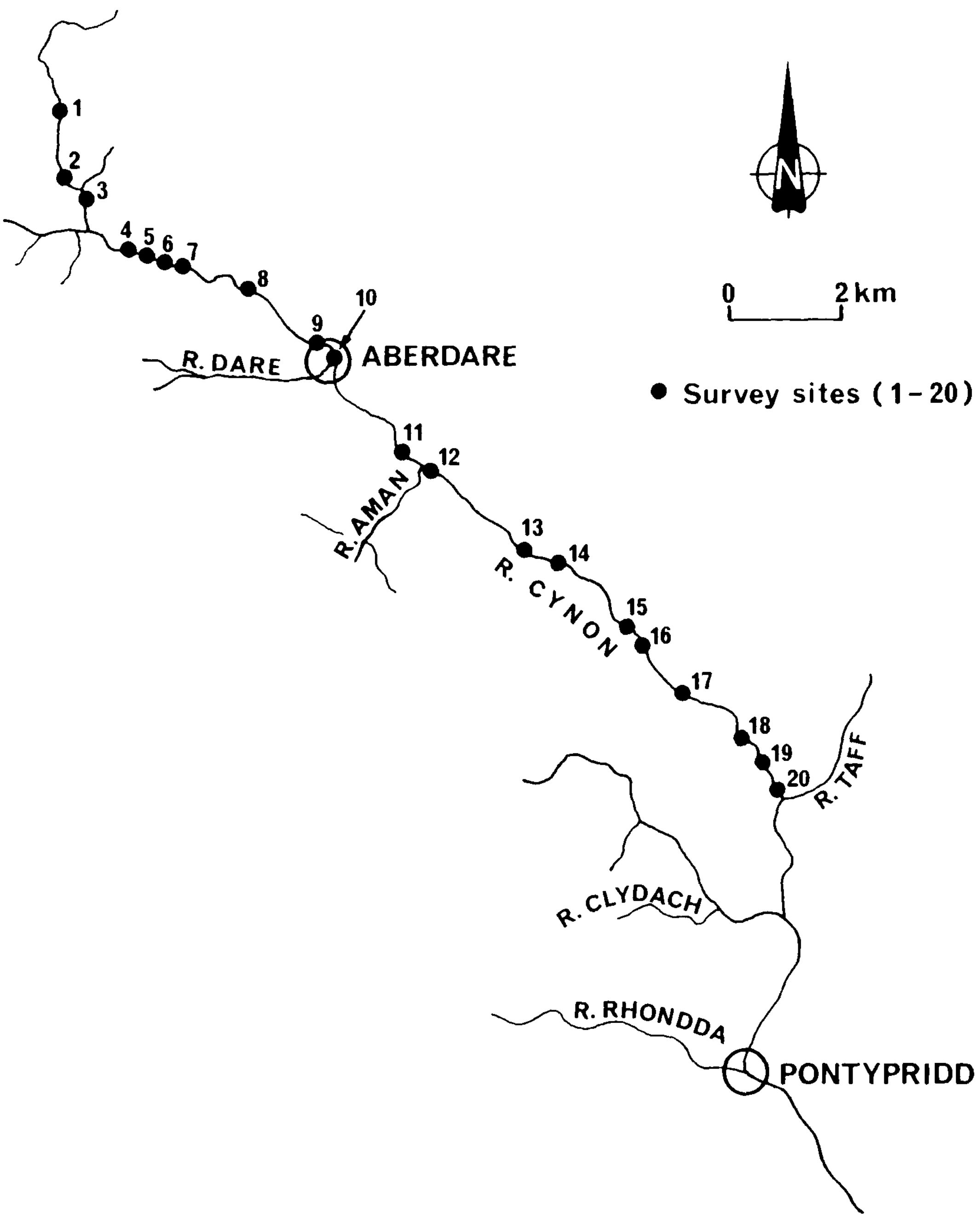
Important in any environmental sampling program design is the definition of the target and sampled populations. Gilbert (1987, p7) stated "the target population is the set of

N population units about which inferences will be made. The sampled population is the set of population units directly available for measurement". As it is not logistically possible to reach every part of a river to assess the litter problem, the target population must be limited to the litter at river sites deemed accessible for sampling purposes. The sampled population is limited by sampling design requirements. In this case, after much consultation with statisticians (Lotwick & Evans, Pers Comm), it was decided that the sampled population should be litter on accessible sites with predominantly natural banks for a length of at least 50 m, where both banks could be sampled.

Initially, all possible sites were noted from an accessibility and size view-point, and for the small scale pilot survey all potential sites (20) were assessed (Fig. 3.1). This was only a feasible option for the small-scale pilot study. A comprehensive site selection procedure was devised for the main survey (Chapter 4).

Due to logistical problems of assessing all litter at a site, representative sampling units were needed to provide an accurate portrayal of the whole site. Dixon and Dixon's (1981) approach of assessing litter within randomly placed transects was adopted for this purpose. Transects used in marine litter surveys were commonly five metres wide. This width was apparently arbitrarily chosen without any justification or discussion regarding implications with respect to sample representativeness. Before applying this method to riverine assessments, literature confirmation was sought regarding the representativeness of transects as sampling units. Gilbertson et al's (1985) minimal area curves approach to ecological studies was adapted to determine whether transect sampling was an appropriate method for river litter assessments, and if suitable, to determine the optimum transect size. Initially developed for determining optimum quadrat sizes for sampling plant species, Gilbertson et al's (1985) method was modified to determine the optimum transect width for sampling litter types (species). The principal is that narrow belt transects are more easily studied, and enable work to be achieved quicker, but wider transects probably yield more reliable data. Therefore, the optimum transect width is one which provides a reliable representation of the litter present, for the minimum amount of work. To determine this optimum width, data was obtained from three survey sites and a minimal area curve was plotted.

Figure 3.1. River Cynon Survey Sites



Starting from the site's centre point, a tape was placed up the river bank, perpendicular to the river flow. A second tape was then placed parallel to the first, at the smallest distance apart (in this case approximately 10 cm). The number of litter types were then counted and recorded. The exact initial distance decided upon was unimportant, as long as it was small enough to contain only one or two items, as recordings were made in relation to a doubling of transect width, and not as a function of the exact width measurement. The transect width was doubled and the number of litter types present again counted. The doubling and counting procedure was repeated until the number of litter types at each doubling of the transect width levelled off. This procedure was carried out at three different sites on the River Cynon and the results from each were plotted as a graph of litter numbers against quadrat width (Fig 3.2). The curve starts to level off at the point that resembles the minimal width necessary to obtain representative samples.

Figure 3.2. Minimal Area Curve: River Cynon Sites

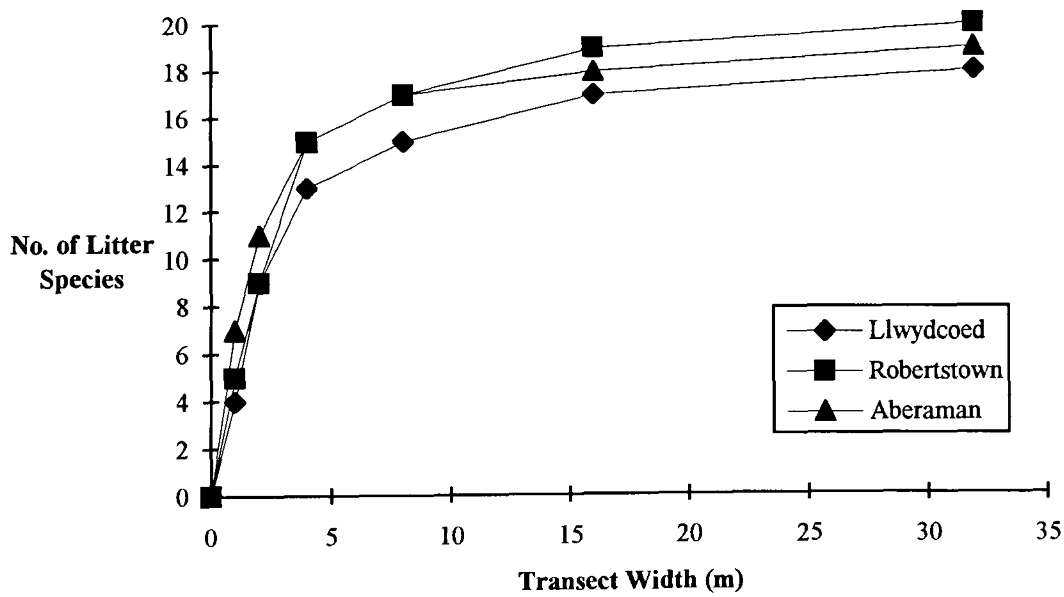


Figure 3.2, shows that the three different sites produced similar curves, with the number of litter types found beginning to level off after approximately five metres. Although the decision regarding the most suitable transect width was somewhat subjective, the graph did indicate that five metres provided a realistic representation for the survey areas. This value was also maintained to establish some consistency with other litter survey designs (Davies, 1989; Dixon & Dixon, 1981).

In Dixon and Dixon's (1981) assessments, three transects were assessed within each site. Again, the representativeness of this approach was investigated, this time applying pre-specified relative error (Gilbert, 1987). A definitive result could not be obtained from this approach as the method was devised for univariate analyses. However, a measure of the appropriateness of transects sampling for each of the litter types was still considered important. The within-site variation of data was measured at three sites (Aberaman, site 12; Robertstown, site 9; Llwydcoed, site 8; Fig. 3.1). Ten, five metre wide transects were positioned at each site, from which quantities of litter types were recorded. Interestingly, calculations showed that for the same pre-specified relative error, differing litter types required vastly differing numbers of transects to be assessed to form a representative sample. Commonly occurring litter types such as plastic sheeting and sewage-derived articles could be realistically represented using only three transects. Conversely, items such as cans, floor covering and wire/cable required up to seventeen transects to be sampled to produce results with the same margin of error. In the case of rare litter items, for example packaging crates, as many as sixty-five transects would be necessary. Results seemed to indicate that any between-site comparisons should only be carried out using those litter types known to have a more uniform within-site distribution. Site comparisons of other litter types would be meaningless as the within-site variation could be greater than that due to the differences between two sites. Gilbert (1987) stressed that these measurements of error should be considered within the realms of realistic sampling procedures. In light of the logistical difficulties of sampling large numbers of transects at each site, it was proposed that the standard three transects would continue to be assessed, but with realisation of the limitations of these results.

In order to position the three five-metre transects, a fixed point was set at each site's upstream boundary. If there was no obvious permanent landmark, an artificial marker was positioned. From this point a random number table was used to determine positions of three non-overlapping transects within the site boundaries. A value obtained from a random number table was paced downstream, and tapes placed up both banks perpendicular to the river flow. A distance of five metres was measured downstream and further tapes placed parallel to those already laid, clearly marking out the belt transect. Following this method, three transects were positioned randomly from which qualitative information was obtained using the survey form/checklist designed (Appendix A6).

Quantitative data was collected from only one transect, which was reduced to just one metre in width. Although minimal, this allowed some data analysis to be carried out, and in the event of quantitative data substitution for qualitative data collection in the final survey, it would mean some insight had been gained in handling such data.

Survey Form Development

From Davies' (1989) work and The Yorkshire Rivers Litter Monitoring Project (1991), it was felt that a more comprehensive checklist was required which would incorporate an improved classification structure. Where possible, similarities were maintained between the checklist developed and those used in other areas of litter monitoring e.g. marine and waste disposal, although neither are directly suitable for riverine surveys. The above resulted in a hierarchical classification scheme being developed which was similar to the International Code of Botanical Nomenclature i.e. family, genus, species.

The three tier structure allowed the checklist to encompass groupings from marine and waste disposal checklists, and was more comprehensive than either of the earlier riverine studies. More detailed non-anecdotal recordings were also sought, for example, specific land-use and road network categories. The Coastwatch UK Marine Litter Survey Form (Appendix A1), was used as an example of non-descriptive data collection; recordings being made by way of multiple choice type answers. Based on this example, the riverine survey form was developed in four main parts; reference information, site information, and data in both qualitative, and quantitative formats (Appendix A6).

Reference Information

This section was designed to give a general description of when and where surveys were carried out. The information was not recorded specifically for data analysis purposes, but mainly to provide important background survey information which could be used and catalogued by any surveyor returning to the area.

Site Information

Site information categories were devised to record details of factors thought to influence riverine litter, for example, vegetation cover and river profile. Recordings were made in the form of multiple choice answers for ease of future data analysis. Site information data would only be statistically analysable when a large number of sites had been surveyed. As the pilot survey was relatively small scale, recordings were made with a view to testing the appropriateness of assessment methods for future use, not for immediate data analysis. Some sections required decisions to be made on the entire site e.g. land-uses, bank type, river pattern, vegetation description and point-source inputs. Other sections required measurements to be made at each of the three transect areas and an average noted for the site e.g. bank profile, river width and river depth (Appendix A6).

The section on land-use and road networks enabled the study to be related to fly-tipping assessments (Plate 3.1). The link between these factors and incidents of fly-tipping has been discussed by Coggins et al (1991) with respect to waste disposal. Although his work does not directly relate to rivers, it was felt that the principles could be adapted for this purpose. Features of Coggins et al's (1991) work were included in the checklist design in order to link into waste disposal/fly-tipping studies.

Bank type and profile were felt to be possible influencing factors in the stranding of litter. Measurements of bank slope were determined at each transect area using a clinometer and, from these, an average slope for the site was calculated.

River width, depth and pattern were all characteristics used by Leopold (1969) in his seminal work on aesthetic quantification of rivers. The categories within each section were identical to those used by Leopold as these were felt to be appropriate to the study. The differing river patterns were defined as follows: (1) *torrent*, violent flow; (2) *pool and riffle*, alternating between flat reaches of low gradient (smooth water surface) and steeper reaches often involving white water; (3) *pools*, low gradient flat reaches with smooth water surface,; (4) *meander*, channels exhibiting curves of considerable symmetry; (5) *braided*, area where the channel is divided by a bar or island due to sediment deposition (Leopold et al, 1964).

Initial surveys indicated that litter was often stranded amongst vegetation. Therefore, a method of describing vegetation at each site was considered important. Features from descriptive botanical methods by Christian and Perry (1953) and Dansereau (1957) were adapted to give a simple means of physiognomic vegetation description.

Plate 3.1. Fly-tipping Site: River Cynon

Plate 3.2. The "Christmas Tree" Effect

The average size categories gave immediate information about the appearance and structure of the community. In the absence of rapid assessment techniques, density was estimated by visual impression only. Christian and Perry (1953) found that recordings on this basis were consistent between different observers when the number of categories were restricted. An additional section not featured in either of the above methods, but felt to be of importance to riverine litter surveys, was the degree of vegetation/river contact. Again this was assessed by visual impression only in three pre-determined categories; minor, average and major (later work clarified these terms; Chapter 4). Immediate point-source inputs were also recorded for each site giving further information on possible sources of sewage of fly-tipped material.

Qualitative Data

The data collection method for the pilot study was primarily developed to determine the potential usefulness of qualitative data for future studies. As such the 5 m wide sampling areas were used for qualitative data collection. Within each transect. presence or absence of checklist items were recorded, with additional information on stranding positions of litter types, e.g. surface, aerial or partially buried.

Quantitative Data

Quantitative data was also collected, but on a smaller scale to prevent having to sample excessively at this time. It was viewed that if qualitative data proved ineffective, quantitative data collection would be substituted and collected in the three five-metre transects.

Attempts were made in the pilot study to assess stratification of litter with height on river banks. To carry out this spatial pattern analysis, a series of 1 m contiguous quadrats were laid along the upstream marker of a belt transect, starting at the water's edge and finishing at the natural limit of the bank (sites chosen with predominantly natural characteristics). Within each quadrat, abundance was measured in the form of density counts, i.e. the number of individuals of particular litter types within a quadrat. This assessment was carried out on both river banks, recordings being made in the second part of the checklist, quantitative data (Appendix A6).

Preliminary observations showed that a proportion of the litter became entangled in bankside vegetation. It was therefore decided that the area marked out by contiguous quadrats would be extended into three dimensions and any litter in vegetation above and within the 1 m wide belt of bank would be collected and taken away for analysis and quantification.

Results and Discussion

Qualitative Data

The problems regarding techniques used to assess litter, and the resulting statistical analyses are roughly comparable to those experienced by ecologists. It was for this reason that much of the proposed survey design and data analysis was based on ecological techniques (Coetzee & Werger, 1975; Ludwig & Goodall, 1978; Ludwig & Reynolds, 1988).

Qualitative data collected from three transects per site enabled sites to be rapidly assessed. Whilst data was rapidly assimilated, major limitations became apparent regarding the number of appropriate statistical methods available for binary data analyses.

Statistical ecology encompasses numerous methods that deal with the exploration of patterns in biotic communities, and some of these methods are capable of dealing with binary data. Litter communities may be substituted for ecological communities for the purpose of this study. Patterns within these communities may be of many different types, including the spatial dispersion of litter types (species) "within" a site, and relationships among litter types "between" sites.

A method considered applicable to this study was interspecific association. Using this method, it was possible to detect the existence of associations between litter types and to calculate indices for measuring the strength of such associations. This affinity (or lack of it) is referred to as interspecific association (Ludwig & Reynolds, 1988). The detection of a pattern does not provide a causal understanding of why such a pattern might exist, but should ideally lead to generation of hypotheses of possible underlying causal factors, which subsequent studies can address.

There were two distinct components to this litter association study. The first, a statistical test of the hypothesis that two litter types were associated or not at a predetermined probability level; the second, a measure of the degree of association. Indices commonly used to measure the degree of association between pairs of litter types are those of Ochiai, Dice and Jaccard (Dejong, 1975).

For the purposes of this research, it was also of interest to measure association of more than a single pair of litter types. Ludwig and Reynolds (1988) recommended the variance ratio test of Schluter (1984) for this purpose. Using interspecific association techniques it was possible to determine if associations existed between several litter types.

The null hypothesis is that there is no association between litter types. If this is not the case, then there are two types of association: positive, meaning the pair of litter types occurred together more often than expected if independent; and negative, meaning the pair of litter types occurred together less often than expected if independent. Litter types may show no association if they are independent, or when positive and negative associations between litter types cancel each other out.

To analyse the data set as a whole (all three transects at each of the twenty sites), Schluter's (1984) variance ratio test was carried out to determine simultaneously if any association existed between the forty-nine litter types.

A data matrix was first constructed of sampling units (transects) against litter types. The null hypothesis was then stated i.e. no association among litter types. Next, the total sample variance for litter occurrence was computed, and the variance in total species number estimated to give the variance ratio (VR). The variance ratio acts as an index of overall litter association. Under the null hypothesis of no association, the expected value is 1. If VR > 1, an overall positive association is suggested and if VR < 1 then an overall negative association is suggested. An additional test statistic W may be computed by multiplying VR by the sample size N. This can be used to test whether the deviations from 1 are significant when W approximates a chi-square distribution.

The variance ratio calculated for the forty-nine litter types was 3.44, indicating an overall positive association between litter types. The calculated test statistic W (204.83) was significantly greater than the critical value (43.77) at the 95% probability level, thereby confirming the positive association.

An alternative use of association analysis is in community classification. As the checklist was arbitrarily devised, based only on similar litter studies and background knowledge of the riverine litter problem, the variance ratio test was used to test the classification system and determine if items within the litter groups (families) were significantly associated. The critical value at the 95% probability level is 43.77. Results indicated that all families were positively associated, with the "sewage-derived" family most associated (W - 309.79), and the "general" family least associated (W - 79.92). These values were as expected, as "sewage-derived" items were the most obvious grouping having a fairly uniform source, and the "general" category consisting of those items that could not reasonably be included in other unrelated families.

Having determined that associations did exist between litter types and that the presence of different litter at sites was not purely random, the next progression was to determine which particular litter types were associated.

The chi-square test was used to detect pair-wise associations of species, with the null hypothesis that the species were independent. From the 2 x 2 contingency table of observed values, expected values were computed for each cell based on the hypothesis of no association. These were then computed using the chi-square test statistic.

$$\chi_\tau^2 = \Sigma \frac{(Observed - Expected)^2}{Expected}$$

The significance of the chi-square test statistic was determined by comparing it to the theoretical chi-square distribution. Since the 2 x 2 contingency table has 1 degree of freedom ((r-1)(c-1)), the theoretical chi-square value at the 95% level is 3.84. If $\chi_t^2 >$ 3.84 for a pair of species the null hypothesis is rejected.

The chi-square test of association was applied to all possible pairs of litter types, and resulted in 31 pairs being significantly associated at the 95% probability level. To aid interpretation of these results, the degree of association was measured.

Although numerous methods were available to calculate indices of association, Hubalek (1982), in his review of index properties recommended three in particular that were generally reliable; Ochiai, Dice and Jaccard. All three indices have a scale ranging from 0 at "no association" and 1 at "maximum association". The Jaccard Index was chosen from these three as it was found to be generally unbiased even on small sample sizes (Ludwig and Reynolds, 1988).

Calculations are made using the proportion of the number of sampling units where both types occur to the total number of sampling units where at least one of the sampling units is found. Jaccard Indices were calculated for all 31 positively associated litter pairs and were then ranked for ease of interpretation (Table 3.1).

$$JI = \frac{a}{a+b+c}$$

where: a = number of sampling units where both species occur.
b = number of sampling units where species A occurs, but not B.
c = number of sampling units where species B occurs, but not A

Table 3.1. Species Associations - Jaccard Indices (ranked from highest to lowest)

Pair Number	Litter Types	Index Value
1	Sanitary Towels:Panty Liners	0.849
4	Sanitary Towels:Cloth/Shoes	0.833
3	Sanitary Towels:Sweet Papers	0.800
30	Sweet Papers:Cloth/Shoes	0.736
7	Panty Liners:Cloth/Shoes	0.717
2	Sanitary Towels:Plastic Sheeting >60 cm	0.709
29	Plastic Bags:Cloth/Shoes	0.627
28	Plastic Bags:Sweet Papers	0.627
27	Plastic Sheeting > 60 cm:Plastic Bags	0.625

With an index scale ranging from 0 to 1 (no association to maximum association), litter pairs with an association index of > 0.5 are considered significant. Of the nine litter pairs that fell into this category (Table 3.1), the highest association was between sanitary towels and panty liners (0.849). This strong association was probably due to the fact that both are common sewage-derived items and as such would be likely to enter the river system at similar points i.e. Storm Water Overflows (SWOs). Sanitary towels also appeared to be strongly associated with cloth, sweet papers and plastic sheeting (0.833, 0.800, 0.709 respectively). These associations were also not considered unusual, as sewage systems are known to be possible sources for all these items (Welsh Water & WRc, 1989). The remainder of the associations were as a result of different permutations of the litter types mentioned above. An additional possible reason for the associations of these particular litter items may be related to the nature by which they are often stranded. Sewage-derived material and other lightweight items such as cloth and plastic sheeting of various sizes tend to get caught on protruding bankside obstructions. The resulting entanglement causes what is known as the "Christmas Tree" effect (Plate 3.2), a phenomenon which causes a great deal of visual offence (SW Echo, 1991; Keep Wales Tidy Campaign, 1992). Such "screening" of litter could lead to these lighter items being stranded in similar areas.

Having calculated associations between litter pairs, the chi-square test was then applied to determine if associations existed between the different sites assessed and between the three transects at each site. Even at the 0.01 probability level, results showed all sites and all transects to be positively associated. Examination of the Jaccard Indices showed that transects within-sites were generally no more strongly associated than those between-sites. From these qualitative results it appears that within-site litter variations can be as great as the between-site variations. If this is the case the representativeness of transects for each site may be questioned; the results from one transect could be dramatically different from another transect even at the same site. No strong associations were apparent between sites, with the highest index value reaching 0.7 and the majority of indices below 0.5. It appears that either significant differences in littering patterns do not exist between sites; the sample size was too small to show differences; or the statistical test was not able to detect the differences.

On completion of these analyses, it was felt that several major limitations negated the benefits of collecting solely qualitative data. The lack of data versatility was felt to be a major problem, with few statistical analyses being appropriate. Even statistical packages which were available (Ludwig and Reynolds, 1988) required very time-consuming data manipulation to carry out relatively simple calculations. In light of one of the major objectives being to compile data for several catchments, it was felt that data manipulation problems alone made qualitative analysis an unfavourable proposition.

Quantitative Data

Although quantitative results were gained from only one of three transects, the broader spectrum of analysis methods available gave the data greater versatility. An area of interest in this survey was the possible stratification of litter with respect to height on the river bank. Again ecological methods, and in particular spatial pattern analysis (Pielou, 1977), appeared to be applicable to this situation.

Three basic patterns may be recognised in communities; random, clumped and uniform. Once a pattern has been identified, a test must be proposed concerning the community structure. Initially, it is important to determine if sampling units are discrete (natural) or continuous (arbitrary) as this influences the type of spatial pattern analysis which can be used. Based on the continuous nature of sampling units in this survey, Ludwig and Goodall's (1978) quadrat variance methods were undertaken. Spatial patterns within a community may be observed by sampling a series of contiguous quadrats. Data was collected in this manner at each site from a series of 1 m^2 quadrats extending up the river bank. For each of the three community patterns, the mean, variance and pattern of individuals within each quadrat are quite different. Quadrat-variance methods are based on examining the changes in the mean and variance of the number of individuals per sampling unit, for a range of sampling units.

It was proposed that two types of quadrat variance methods would be used, the paired-quadrat variances (PQV) and the two-term local quadrat variance (TTLQV) method. PQV utilises changes in quadrat spacing to provide spatial pattern information, whilst TTLQV utilises changes in quadrat size via the blocking or combining of adjacent quadrats to determine pattern intensity and range of densities present. A plot may be constructed of variances against the series of block sizes or spacings for both PQV and TTLQV methods. These graphical representations may then be interpreted statistically using Ludwig and Goodall's (1978) RPQV (random paired quadrat variance) procedure to test the significance of variance peaks. These methods would indicate which litter items are stratified and the pattern which they follow.

During the pilot survey period, limitations of the quadrat-variance method of spatial pattern analysis became apparent. At several sites, river banks did not extend high enough to allow for many recordings to be made. It was also noted that although litter items were found high up on the banks at some sites, this was less frequent than previously thought. Problems resulting from this lack of data arose when variances of litter items were calculated using both PQV and TTLQV methods. Limitations in the number of block size/spacings resulting from the lack of data brought into question the accuracy of the results and subsequent plots. Following Ludwig and Goodall's (1978) guidelines on spatial pattern analysis, it was decided that under the circumstances it would be unwise to base any conclusions on the results. As such, the quadrat-variance methods were deemed unsuitable for the riverine study and were excluded from the survey which was subsequently redrafted for future use.

Quantitative data was analysed further, using the SPSSx statistical software package (Norusis, 1983). Results from individual quadrats were combined to produce data representing a 1 m wide belt transect up both river banks. Obvious data limitations were apparent due to the small area sampled and the use of only one transect to represent a site. Nevertheless, providing these limitations were considered when interpreting the results, data could still be used to indicate whether certain statistical tests would be of future use.

Initially, to determine the appropriateness of parametric or non-parametric tests, normality of the data set was tested using the Kolmogorov-Smirnov one sample non-parametric test (Miller & Miller, 1988). The test compared the cumulative frequency distribution for a litter type against that which would be formed by a normal distribution. The Z value computed was calculated as a measure of the vertical difference between the two cumulative frequency curves. The larger the calculated Z value, the more probable the distribution was not normal. A probability value based on this was also computed, and if less than 0.05 indicated a significant departure from normality.

Results indicated that only four litter types, sanitary towels and plastic sheeting of three size categories, had Gaussian (normal) distributions. These particular litter types were the most numerous and most commonly recorded items. All other litter species gave probability values of less than 0.05 and were therefore significantly non-normally distributed, reflecting their sporadic occurrence.

Having determined the distribution (variation) of each litter type, an obvious progression was to study the covariation between litter types. One popular non-parametric measure of covariation, based on ranking of abundance, is the Spearman rank correlation. Before carrying out this test, it was necessary to modify the data set by eliminating litter types which had empty data sets in order to prevent spurious correlations being calculated (Ludwig and Reynolds, 1988). Firstly, a null hypothesis was formulated; that litter types ranked in order of abundance are uncorrelated. Pair-wise correlations were then calculated, ranking the abundance data of each litter type (X_i Y_i) in order, from largest to smallest values. A perfect correlation between two litter types would result if $X_i = Y_i$, for all i's. Differences between X_i, Y_i values are therefore an obvious measure of the disparity between two sets of rankings (d_i). The larger the d_i value the less the two variables are correlated. Unfortunately, it is not possible to use the d_i values to compute a correlation coefficient directly because the negative d_i's would cancel out the positive ones. This difficulty is overcome by utilising d_i^2 rather than d_i. From the sum of squared disparity values, Σd_i^2, the correlation coefficient r_s may be calculated using the formula:

$$r_s = 1 - \frac{6\Sigma d_i^2}{N^3 - N}$$

Spearman rank correlation coefficients (r_s) calculated in this way may range from -1 to +1, and have no units. To test the null hypothesis, that litter types ranked abundance are uncorrelated, calculated values may be compared to critical values stated at pre-specified probability levels.

SPSSx rank correlation output is given in a slightly different format. Instead of arbitrarily deciding the probability level with which to compare the results, the computed output gives the probability level at which the litter types are correlated. Consequently, any pair of litter types with a probability value of < 0.05 is said to be correlated.

Table 3.2. Significantly Correlated Litter Pairs

Correlated Litter Pairs	Significance
Sanitary Towel:Panty Liner	0.000
Panty Liner:Tampon	0.019
Sanitary Towel:Tampon	0.007
Plastic Sheeting < 30 cm:Plastic Sheeting 30-60 cm	0.006
Plastic Sheeting < 30 cm:Plastic Sheeting > 60 cm	0.030
Plastic Sheeting 30-60 cm:Plastic Sheeting > 60 cm	0.000

Results (Table 3.2) showed that although correlations were present between litter pairs, many occurred between types found infrequently and could therefore not be regarded as conclusive. Of the more common litter types, correlations were shown between sanitary towels, panty liners and tampon/applicators. Plastic sheeting appeared to be correlated with other plastic sheeting of differing sizes, but not with any sewage-derived litter, as indicated in the qualitative results from litter associations. This result may highlight one of the problems of using qualitative data in this sort of survey. Associations between plastic sheeting and sewage debris may have been calculated because of their common occurrence at sites. The associations shown by the qualitative data may have led to the hypothesis that the plastics were introduced to the system from the same sources as the sewage-derived litter, hence their association. However, it appears that although both these species are present at the same site, their abundances were not correlated significantly.

Major limitations of this analysis appear to arise from the number of zeros present in the data set. It is likely that improvements could be made if a larger data set was collected. A second problem, inherent to this type of statistical test, and not related to sampling limitations, is a realistic interpretation of the results. Even from this fairly small pilot study, the number of possible pair-wise permutations makes discussion of results and formulation of conclusions difficult. Despite these problems, Spearman rank correlation coefficients were viewed as an initial determinant of possible covariation between species, providing the number of zero recordings were kept to a minimum. More appropriate for such situations, when an expanse of coefficients are calculated, are multivariate methods of pattern recognition such as cluster and principal component analysis (Derde & Massart, 1983).

Cluster analysis may be used to place similar objects or variables into groups or "clusters". In this case, cluster analysis was used to discover where the certain litter types occurred in a similar manner throughout the 20 sites. Firstly, a measure of the distance of the variables amongst all possible pairs was obtained. This process may be visualised as plotting a point marking the quantity of each litter type at each site, in twenty dimensional space (one dimension for each site). Secondly, a distance matrix is formulated by measuring distances between points, and values are then used to produce a hierarchical tree-like structure called a dendogram. Dendograms demonstrate graphically, in two dimensions, similarities between variables by the varying distances at which the groups are formed. The closer a group is formed to the x-axis, the stronger the similarities between its constituent parts.

Results (Fig. 3.3, Table 3.3) represent only those litter types recorded and appear to be greatly affected by the number of infrequently occurring litter types. The litter types which are most strongly grouped e.g. container drums (17) and signs/cones (32), and glass bottles (27), are those which were recorded at only one of the twenty sites. Their sporadic occurrence appears to have caused this strongly correlated group. Obviously results like this could be somewhat misleading if referral back to original data does not take place. Of the more common litter items, groups were formed between furniture (13) and cloth/shoes (34), fencing (7) and metal sheeting (18), and sanitary towels (1) and panty liners (2). Interesting to note is that joining the closely correlated sanitary towels and panty liners are tampon/applicators (3) and toilet paper (4), forming a distinct sewage-derived group. The cluster analysis approach would therefore appear to be a very useful tool for indicating patterns within the data set. It was felt that if the number of zero recordings were reduced the method could certainly be used in future analyses.

Figure 3.3. Hierarchical Cluster Analysis
(Dendogram using Average Linkage between Groups: Key Table 3.3)

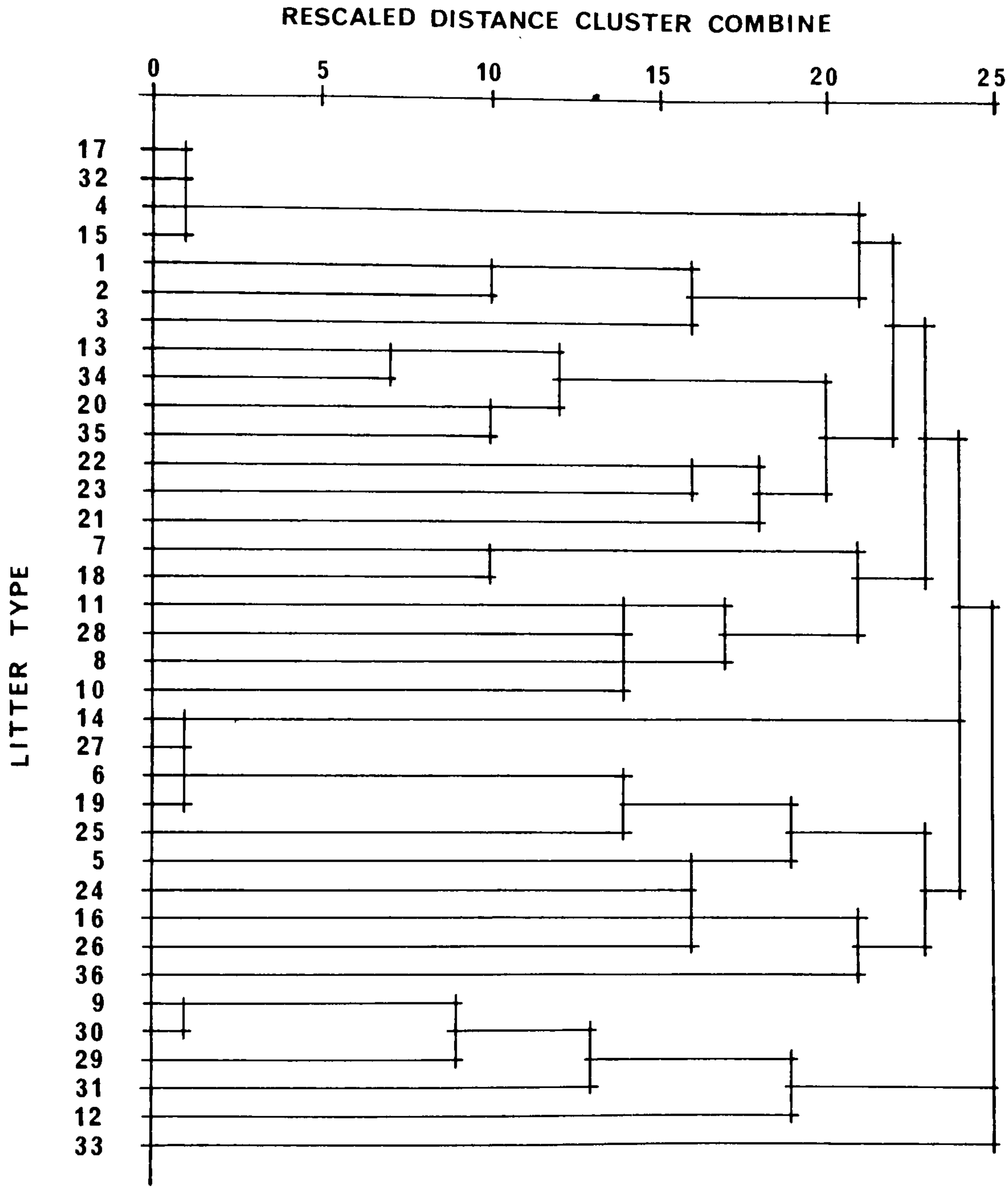


Table 3.3. Litter Identification Key

FAMILY	GENUS	No.	SPECIES
SEWAGE DERIVED	Feminine Hygiene	1	Sanitary Towels
		2	Panty liners
		3	Tampon/Applic.
	General	4	Toilet Paper
		5	Cotton Buds
		6	Other/Uniden.
HOUSING MATERIALS	Combustible	7	Fencing
		8	Hardboard/Wood
		9	Other/Uniden.
	Non-combustible	10	Brick/Rubble
		11	Floor Cover
		12	Other/Uniden.
HOUSEHOLD (LARGE)	Brown Goods	13	Furniture
		14	Mattress /Foam
	White Goods	15	Other/Uniden.
HOUSEHOLD (SMALL) /COMMERCIAL /INDUSTRIAL	Metal	16	Cans/Tins
		17	Container Drums
		18	Sheeting
		19	Other/Uniden.
	Plastic	20	Polystyrene
		21	Sheeting <30 cm
		22	Sheeting 30-60 cm
		23	Sheeting >60 cm
		24	Plastic Bags
		25	Sweet Papers
		26	Bottles
	Glass	27	Bottles
		28	Other/Uniden.
TRANSPORT ASSOCIATED	Motor Vehicles	29	Cars/Parts
		30	Motorbikes/Parts
		31	Other/Uniden.
	General	32	Signs/Cones
GENERAL	Packaging	33	Cardboard
	Miscellaneous	34	Cloth/Shoes
		35	Rope/Fishing Line
		36	Other/Uniden.

Principal Component Analysis (PCA) is an alternative method of pattern recognition which aims to identify principal components that explain correlations among a set of variables (litter types). In this case, the method aims to condense information of litter types from twenty dimensions (twenty sites) to two or three dimensions which may be more easily interpreted. If once again points may be visualised as being plotted in twenty dimensions, the first principal component, a new variable, is chosen to represent the condensed data set, whilst still maintaining the maximum variation among the points. If a further principal component is desired, this is chosen to explain as much of the data variation as possible which is left unexplained by the first principal component. In addition to providing a two or three-dimensional representation of the data, principal components analysis also calculates "loadings" to indicate the significance of each of the variables in determining the data structure. The higher the loading for a particular variable, the greater the importance the variable has in determining that component. If a situation arises when many variables have high loadings, making interpretation of the underlying reasons problematical, a method known as rotation may be used to simplify matters (Derde & Massatt, 1983).

Principal component analysis may be carried out in three basic stages. Initially, a correlation matrix is computed. From the matrix, principal components are then extracted, and finally the factors are rotated, if necessary, to aid interpretation.

The quantitative litter results were first output in the form of a correlation matrix. Principal components (factors) were then extracted from this matrix. The first three factors accounted for 19.4, 15.6, and 10.7 percent of the variation in the data respectively. Another fifteen factors were further extracted before accounting for all variance in the data. The importance of each litter type in the determination of these factors was presented in a loadings table. A warning was also issued along with these results, stating that the correlation matrix was ill-conditioned. This problem appeared to result from the number of zero values in the data. On the basis of this warning, it was decided not to proceed with the analysis as the significance of any further results computed would be questionable. However, the future potential of principal component analysis as an interpretation tool for riverine litter results was obvious.

Sampling Regime Modifications

Although only a few methods of quantitative data analysis were attempted, results indicated these to be far more suitable than the methods undertaken for qualitative analysis. The most significant overall limitations appeared to be the small data set available and the number of zero values. With the assumption that this would be largely rectified if future surveys were aimed primarily towards quantitative data assimilation, it was felt that quantitative data should be recommended. Further justification of this choice was given in that S. Wales' riverine litter problem is seen as very much a "worst case scenario". With the long-term aim being to compare data from differing UK regions it was summized that if quantitative data could be realistically collected in the S. Wales area, the task would be very much simpler for any other region. An additional benefit of abundance data is also that the option of reduction to qualitative data at a later date is always a possibility.

Therefore, it was envisaged that for future surveys, the overall sampling regime would remain the same, except for the introduction of quantitative data collection in place of qualitative data. An additional alteration to the method was that future sampling would be limited to only one bank. This change was brought in for purely practical purposes due the difficulties encountered in attempting to assess both banks. All other changes made in the sampling procedure were as a result of survey form modifications.

Survey Form Modifications

Several sections of the survey form underwent modification, as mentioned previously, due to problems which became apparent during the pilot study (Appendix A7). In the site information section, the site bank profile determination was considered too specific and time consuming for its purpose. As such, a simpler graphical method, representing four basic riverine profiles was devised (Appendix A7). From these, the profile considered to most closely represent a site would be recorded. A similar approach was taken in an attempt to simplify the vegetation description method. A reduction was made to four categories (grades A - D) ranging from dense to sparse vegetation (Appendix A7). To aid identification of these grades, photographic examples of each were given at the rear of the form for comparative purposes. This type of photographic comparison is an accepted assessment method as demonstrated in the Code of Practice on Litter and Refuse (HMSO, 1990). In addition to the removal of the qualitative data forms, the quantitative data form was altered for the collection of data in complete transects rather than split into separate quadrats. Also resulting from this change towards quantitative data collection was the removal of litter stranding position assessments. The checklist itself was also modified to include additional litter items found in significant numbers during the pilot study.

CHAPTER 4

BASELINE SURVEY

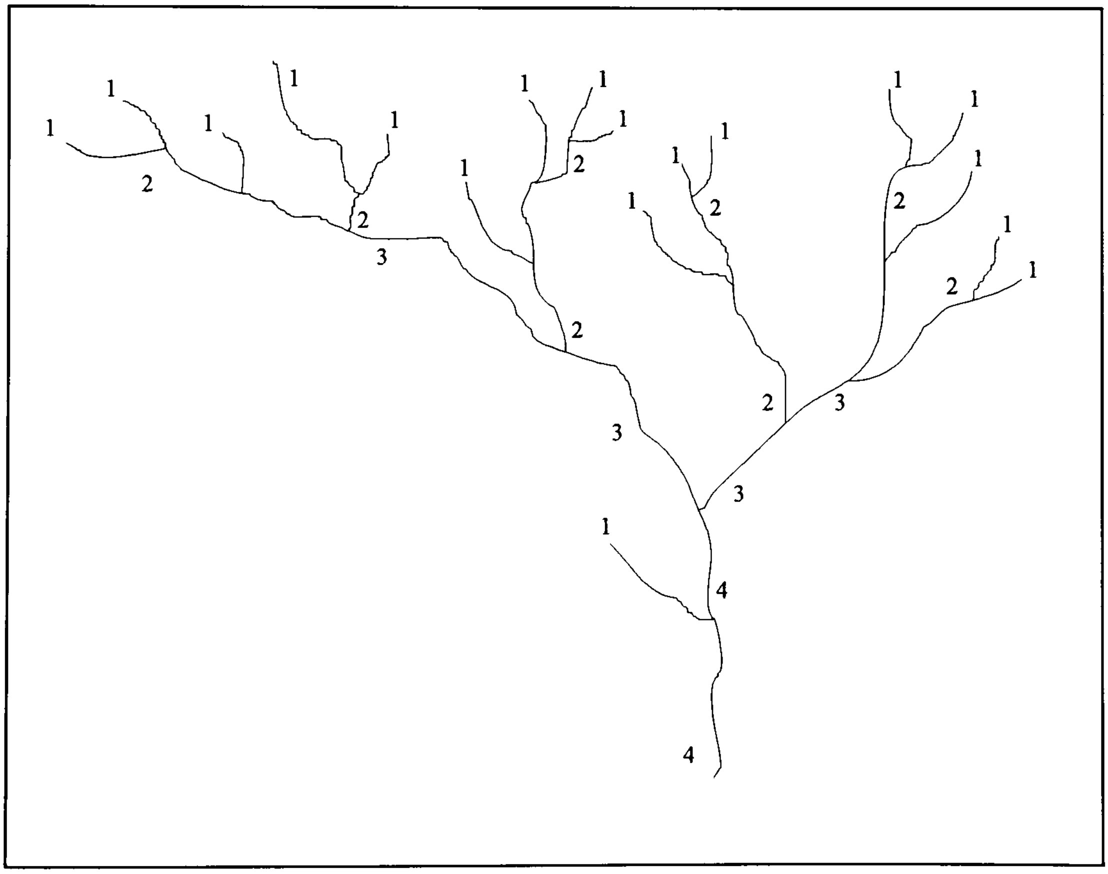
Sampling Regime

Survey methods developed from the pilot study (Chapter 3) were applied to gather baseline data from three river catchments, the Taff, E. Lyn and Avill, to provide an overview of the riverine litter problem. A sampling regime was necessary to ensure representative data collection and to determine number and position of sites within each catchment. As mentioned earlier (Chapter 3), several sampling approaches were considered (Dixon & Dixon, 1981; Davies, 1989; Ribic et al, 1992) but none were considered directly applicable in this case. As such a new systematic approach was developed on the basis of catchment size and hydrology.

Initially all potential survey sites were included, i.e. those that were reasonably accessible and had continuous lengths of accessible banks. Based on a 50 sites per 100 km^2 catchment area ratio, a decision was made regarding the number of sites to be sampled within each catchment. A minimum number of sites (20) was also stipulated to ensure an adequate representation of smaller catchments. This value was based on insight gained in the pilot survey (Chapter 3). Previous river surveys, e.g. Davies (1989) utilised stratified random sampling methods, designating one site for every 2 km reach. The selection of a site within the reach was the random element present in this approach. However, accessibility problems often limited selection to just one suitable site. Therefore, instead of using distance measurements to divide the river, it was decided that more random selection could be achieved using the river's natural subdivisions.

Horton (1945) in his drainage analysis study, was the first to propose the existence of a relationship between stream length and order. This work was later simplified by Strahler (1957) but the general concept remained the same. Stream order was defined as a "measure of the position of a stream in the hierarchy of tributaries" (Hynes, 1970, p 12). First-order streams are those which have no tributaries and are by definition the smallest streams marked on a 1:24,000 scale map. At the confluence of two first-order streams a second-order stream is formed. Likewise, when two second-order streams converge they become third-order and so on. If a stream is joined by a tributary of lower order than itself, no change in order results (Fig 4.1).

Figure 4.1. Diagrammatic Representation of Stream Ordering



Hynes (1970), suggested that the concept of stream ordering was of considerable value as an objective means of classifying watercourses. On this basis, "stream ordering" was calculated for each catchment. Site positions were then limited to areas with only the highest three orders, thus eliminating the inaccessible higher tributary sources. River lengths of each order were measured and totalled. Sites were then allocated to each order in numbers proportional to river length (Gilbert, 1987). In this way the order with the greatest stream length was represented by the largest number of survey sites (Table 4.1). Exact site locations were designated within catchments using random number tables to select specific sites from potential ones. These sites were then surveyed in both summer and winter using the checklist and methods proposed in the pilot survey.

Table 4.1. Site Allocation Summary

Catchment								
Taff			**E. Lyn**			**Avill**		
Order	% River Length	No. Sites	Order	% River Length	No. Sites	Order	% River Length	No. Sites
5	30	15	5	35	7	---	---	---
4	46	23	4	28	6	4	17	4
3	24	12	3	37	7	3	31	6
---	---	---	---	---	---	2	52	10

Sampling Site Allocation

Based on catchment size, numbers of sites to be surveyed for each river were calculated; Taff (50), E. Lyn (20), and Avill (20). The small sizes of the Avill and E. Lyn meant the stipulated minimum of twenty sites had to be implemented. Stream orders calculated for each catchment showed that both the Taff and E. Lyn were order 5 rivers, and would therefore be assessed in only 5, 4 and 3 order regions; whilst the Avill being a fourth-order river would be assessed in the 4, 3 and 2 order regions. Proportions of river length in each designated order were then measured to ensure proportional representation of sites (Table 4.1).

Results and Discussion

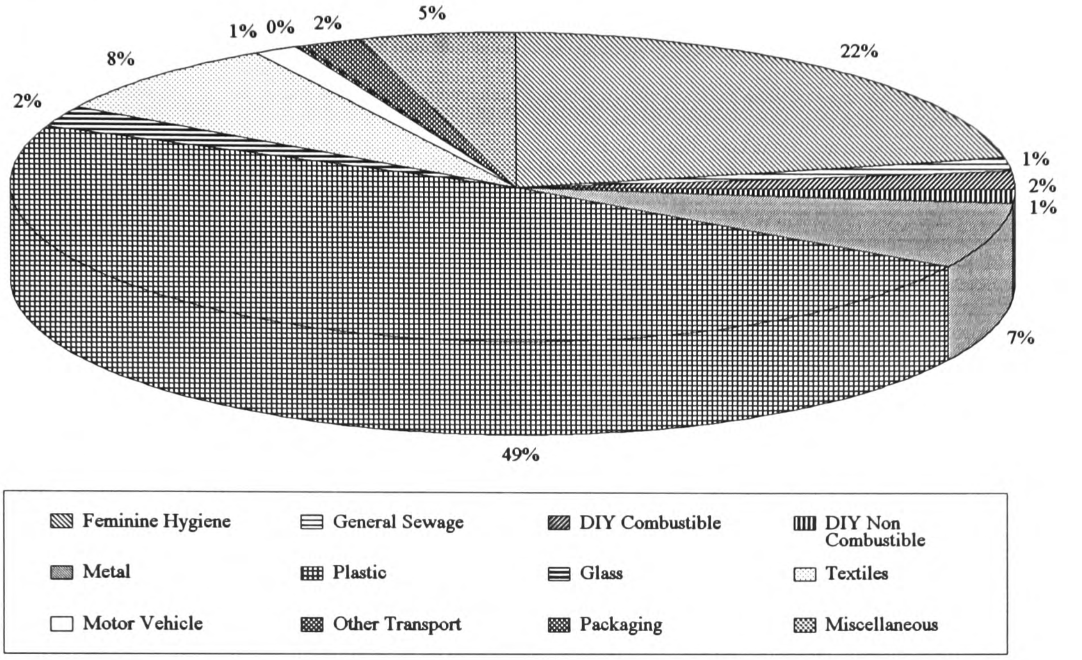
Taff Catchment

Due to the size of the Taff catchment, a much larger data set was gathered than for the E. Lyn or Avill. The total litter items found at the fifty sites, assessed on two occasions using three five-metre transects were 8687; resulting in an average of 584 items per 100 m of bank length. This figure may not be a true representation of the whole catchment, because the upper-most source rivers, likely to be most pristine were not included in this survey.

Litter Composition

Results from both summer and winter surveys were initially combined to assess the overall composition of litter on the Taff (Fig. 4.2). Plastics constituted almost half of all litter found. When divided into constituent parts, plastic sheeting formed 57 % of total plastic. Sewage-derived items were also found in considerable quantities; feminine hygiene products alone forming 22 % of all waste recorded. Other general sewage items formed a comparatively small 1 % of all litter. The remaining waste groups found in high numbers were textiles (8%), metal (7%) and miscellaneous items (5%). In total, only twelve groups are represented on Fig. 4.2. Brown and white goods were found in such small quantities, eight and two items respectively, in comparison to other wastes that they did not form visible graph sectors.

Figure 4.2. River Taff Litter Composition



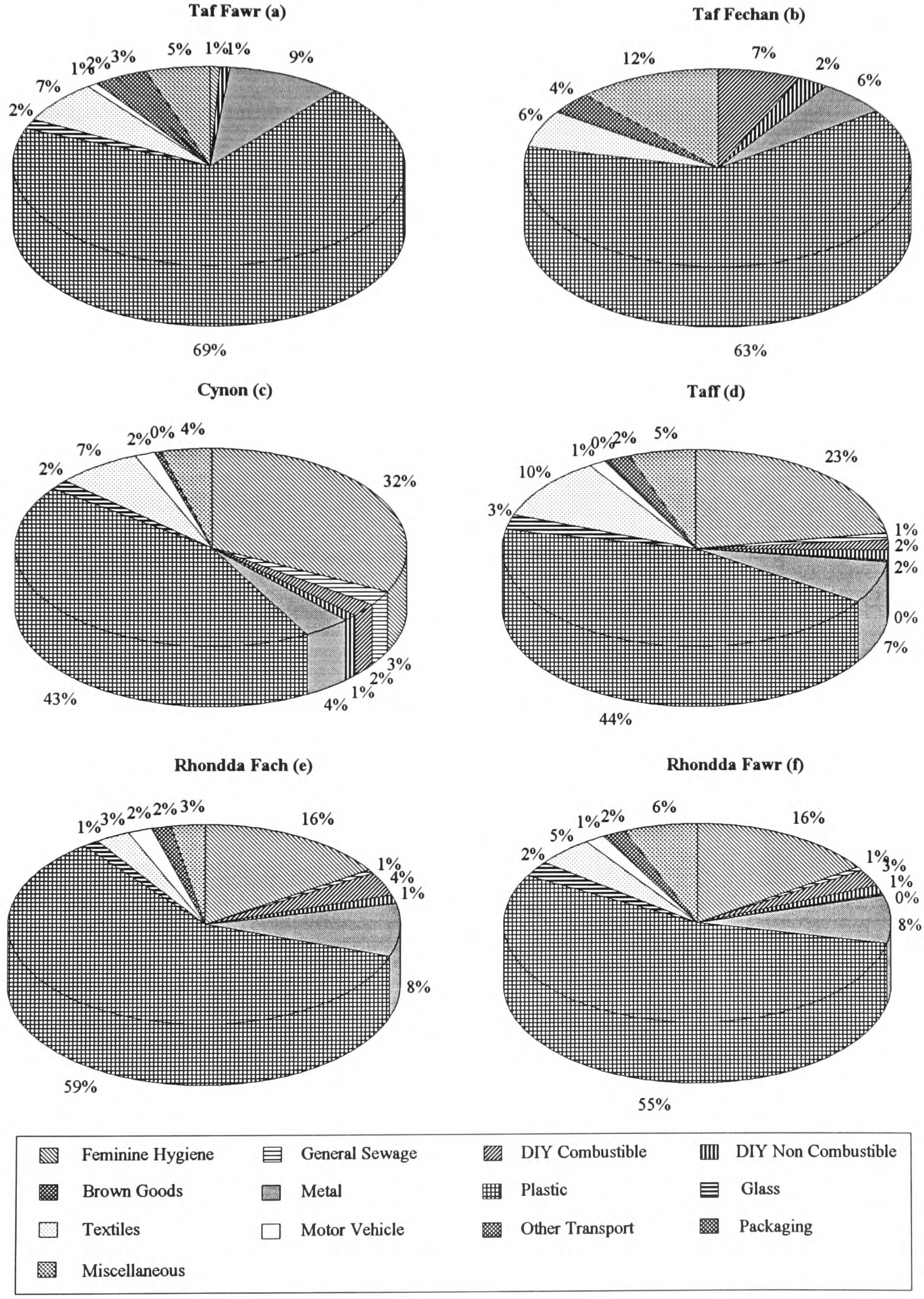
Litter Composition in the Taff's Tributaries

Total litter composition results were then subdivided into litter from the Taff tributaries to determine the uniformity of this litter profile for the whole catchment (Fig. 4.3). In the Taf Fawr and Taf Fechan (Fig. 4.3a & 4.3b), the upper-most reaches of the Taff, only small quantities of litter were recorded. Plastics still formed the majority of items found, but in these upper reaches sewage items were almost completely absent. Feminine hygiene products constituted only 1% of litter on the Taf Fawr, whilst no sewage-derived material was found on the Fechan. Both tributaries are situated above the first major conurbation and as such would not be expected to exhibit sewage pollution to any serious level.

The Rhondda Fach and Rhondda Fawr (Fig. 4.3e & 4.3f) are tributaries with considerable urbanisation along their lengths. They demonstrated almost identical composition and showed a much closer likeness to the Taff overall litter profile than its headwater streams. Contrastingly, the River Cynon (Fig. 4.3c), also a fairly urbanised tributary, showed a very different profile. For example, plastic components formed only 43% of total litter. This was however counteracted by a rise in sewage-derived material. Within the Cynon, feminine hygiene products alone constituted 32% of all litter, with an additional 3% for general sewage items. A plot was also generated for the River Taff from its formation at Merthyr Tydfil to its seaward boundary (Fig. 4.3d). This did not appear to differ significantly from the overall catchment profile.

Results from subdividing the data set in this manner do not appear to agree directly with Davies and Boden's (1991) work on the River Taff tributaries in which the Rhondda valley was highlighted as the most sewage polluted area. This discrepancy could be the effect of the different assessment techniques used or a change in the litter composition between the two sampling periods. The NRA has recently placed considerable emphasis on addressing malfunctioning Storm Water Overflow problems within the Welsh Region. Reductions in sewage-derived material in the Rhondda valley between the two periods could therefore be reflecting the effectiveness of these measures.

Figure 4.3. Litter Composition of River Taff Tributaries

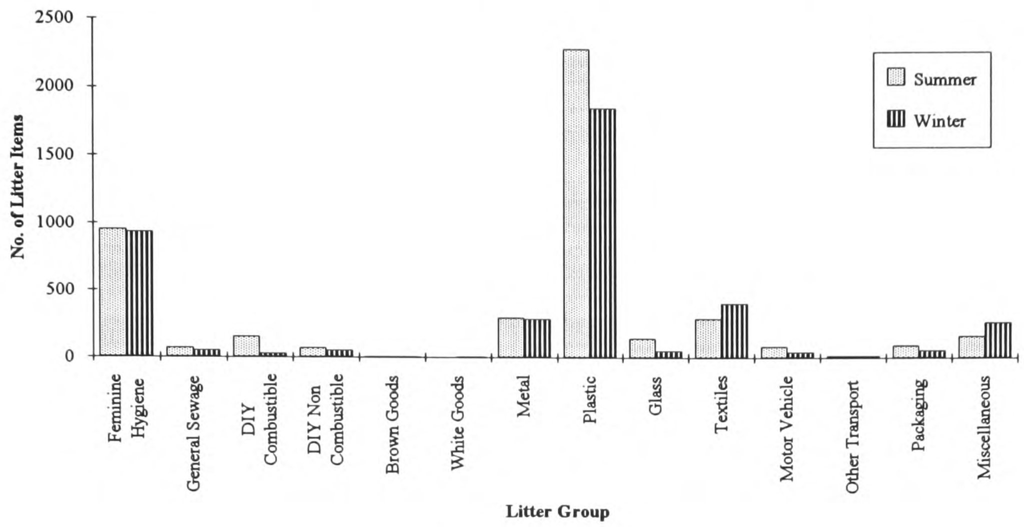


Seasonal Litter Variations

The complete data set was then subdivided into summer and winter assessments to investigate possible seasonal variation in litter composition (Fig 4.4). In addition to plotting these results, paired t-tests were carried out for the fourteen litter subgroups between summer and winter to determine if differences were significant at the $P <= 0.05$ level. The t-test measured mean and standard deviations of differences for summer and winter results from which a t statistic was calculated (Appendix C).

Total item numbers found were less in the winter (4058) than summer (4629), but this overall trend was not statistically significant. However, significant differences were present within seven of the fourteen sub-groups tested. Five of the seven groups showed significant decreases from summer to winter; DIY combustible, plastic, glass, motor vehicle, and packaging. Whilst results did not indicate the reasons for this trend, decreases in these items during the winter may be due to the more dynamic conditions at this time exerting a cleansing effect on the river. The two other groups with significant seasonal differences, textiles and miscellaneous items, were more abundant during winter assessments. Unidentifiable litter items, often fragments of larger objects, were recorded under miscellaneous. It is therefore possible that such items increased in winter due to increased litter fragmentation. Increased textile numbers during the winter is however more difficult to explain and will be considered in future multivariate analyses. Surprisingly, sewage items did not increase in the winter assessment, even though inputs were likely to be at their highest due to SWO discharges. Instead, feminine hygiene products and general sewage items both showed slight reductions in numbers. It is possible that an equilibrium exists whereby increased inputs during winter are equalled by increased output to sea during high flows, or by physical breakdown. If this was the case a build-up of sewage items on the river bank with time may not be apparent.

Figure 4.4. Seasonal Composition of Litter on the River Taff



Fly-tipping

Following this overview, a more in-depth analysis was undertaken using site information recordings. At each site, indexed recordings were made of characteristics viewed as potentially important in relation to litter, based on prior observations and facets of related work. Land-use, road network and vehicular access categories were included to tie in with fly-tipping research. For fly-tipping in non-riverine areas, Coggins et al (1991) considered these to be the salient factors in determining the tipping potential of an area. As fly-tipping is a known problem on rivers, these characteristics were adopted for inclusion in the river survey. At each site presence or absence of tipping was recorded together with some indication of the type of tipping involved, i.e. household or commercial. The road network in the surrounding area was assessed, in addition to the presence of any direct vehicular access within 50 m of the site. Land-use was also designated for the area, as one of ten possible categories.

Results from these recordings were analysed by a simple cross-tabulation technique (Table 4.2) and revealed some interesting trends. From all fifty sites assessed, exactly half of them had a fly-tipping problem. Initially the simplest data split was considered, sites with or without direct vehicular access. Sites without vehicular access were tipped in 28% of cases, in contrast to sites with access, of which 60% were tipped. These results seem to indicate that the presence of a road or track within close proximity to the river considerably elevated the chances of that site being fly-tipped. It was noted, from observations made during the assessments, that many of the tipped sites without vehicular access showed signs of boundary tipping. It would therefore be useful to include a boundary tipping category in future surveys.

The split into three road network types showed less conclusive results. Fifty-six percent of sites with 'A' graded roads were tipped as opposed to 42% with 'B' graded roads and 45% in sites with ungraded roads. This category appeared to be less influential and was regarded as unnecessary for future surveys.

Table 4.2. Cross-tabulation of Site Information Categories Related to Fly-tipping

		'A' Grade Roads			**'B' Grade Roads**			**Ungraded Roads**			**Grand**
Access	Land Use	NoTip	Tip	Total	NoTip	Tip	Total	NoTip	Tip	Total	**Total**
No	Residential	1	0	1	2	1	3	0	0	0	4
	Open Space	3	0	3	0	0	0	1	0	1	4
	Indus/Com	0	1	1	0	0	0	0	0	0	1
	Res/Open	0	0	0	0	0	0	2	0	2	2
	Indus/Open	0	1	1	0	0	0	0	0	0	1
	Com/Open	0	1	1	1	0	1	0	0	0	2
	Total	4	3		3	1		3	0		14
Yes	Residential	1	1	2	1	0	1	2	1	3	6
	Industrial	0	0	0	0	1	1	0	0	0	1
	Open Space	1	3	4	0	0	0	2	1	3	7
	Res/Indus	0	3	3	0	0	0	1	1	2	5
	Indus/Com	0	2	2	0	0	0	1	1	2	4
	Res/Open	2	0	2	0	1	1	1	4	5	8
	Indus/Open	1	1	2	0	0	0	1	1	2	4
	Com/Open	1	0	1	0	0	0	0	0	0	1
Total		6	10		1	2		8	9		36
Grand Total		10	13	23	4	3	7	11	9	20	50

Table 4.3 shows in more detail the cross-tabulation of fly-tipping waste types and land-use categories. Caution was necessary when interpreting results relating to land-use as in some cases only a few sites were recorded in each group. Of the groups with larger data sets, residential/industrial and industrial/commercial mix had the highest tipping incidence (80%). Industrial/open (60%) and residential/open (50%) also had fairly high tipping levels. It appeared that tipping was most prevalent in mixed land-use areas, and that industrial areas in particular were susceptible to tipping.

Table 4.3. Cross-tabulation of Land-use and Fly-tipping Categories

	Fly-tipping				Total	Grand
Land Use	**None**	**1.Indus/Com**	**2.Household**	**3.Combination**	**1,2,3**	**Total**
Residential	7	0	3	0	3	10
Industrial	0	1	0	0	1	1
Open Space	7	1	2	1	4	11
Res/Indus.	1	1	1	2	4	5
Indus/Com	1	0	4	0	4	5
Res/Open	5	0	4	1	5	10
Indus/Open	2	2	1	0	3	5
Com/Open	2	1	0	0	1	3
Grand Total	25	6	15	4	25	50

It was possible to demonstrate this more clearly by applying the mixed land-use results to both categories from which it was derived, thus forming only four land-use types. Results from this unbiased data manipulation showed a clear ranking of land-uses and related tipping incidents. Sites with an industrial element were tipped in 75% of cases, followed by commercial areas (62%), residential (48%) and lastly open space (45%). From these results it appeared that land-use followed by direct access were the most important factors in determining a site's fly-tipping potential.

Regarding the types of tipping found, household-type waste was shown to be the most common form tipped in the Taff catchment. It may therefore have been expected that residential land-use areas would show the highest predominance of tipping. This, however, was not the case. To investigate these results more thoroughly, land-use types and their respective data were once again reduced to only four land-use categories, by allocating results from mixed land-use areas to their component parts. These results helped clarify which forms of tipping predominated in the main land-use categories (Table 4.4). Within all land-use types, household tipping was the most common form of tipping. Therefore, it would appear that although industrial areas are most commonly tipped, material found in such areas consists of more household than industrial/commercial waste. It is plausible that members of the public wanting to tip waste would employ a 'Not In My Back Yard' (NIMBY) type principle, and would take the waste to industrial areas, which offer a certain amount of seclusion and are perhaps viewed as aesthetically less valuable. An alternative explanation could also be that industrial areas are disposing of small quantities of household-type waste from collection sites within their premises, e.g. cafeterias, to avoid the cost of removal. A warning should be made regarding these results, that concerns the subjective categorisation of tipping types. Coggins et al (1991) discussed the problems of determining waste origins in their fly-tipping work. Caution was therefore administered when categorising tipping types, and if doubt existed regarding origins, the combination category was selected.

Table 4.4. Summary of Tipping Types and Land-use

	Type of Tipping			
Land-use	**None**	**Indus/Com**	**Household**	**Combination**
Residential	52 %	4 %	32 %	12 %
Industrial	25 %	25 %	38 %	12 %
Open Space	55 %	14 %	24 %	7 %
Commercial	38 %	12 %	50 %	0 %

The predominance of household tipping within the Taff catchment could indicate shortcomings in public waste disposal services in the area, or may instead result from low public awareness regarding available disposal options. In taking steps towards reducing tipping within the catchment, an understanding of these disposal problems is crucial and is strongly recommended as an area for future investigation.

Cross-tabulation of site information categories related to fly-tipping were based on identification of point-source tipping sites. A question that arose from this was whether actual site litter items would quantitatively reflect the same trends, i.e. could the survey detect fly-tipping through composition and quantities of litter at sites? However, such results were likely to be less conclusive as the composition of survey sites reflects not only its point-source inputs, but also its upstream inputs and outputs with time.

Of the six main litter groups (sewage-derived, building/DIY related, consumer durables, household/commercial/industrial, transport associated, general) only four were tested, as sewage-derived litter was not relevant to fly-tipping and consumer durables did not contain enough recordings. An Analysis of Variance (ANOVA) was used for the comparisons to allow testing of more than two sample means. To adhere to ANOVA limitations, Kolmogorov-Smirnov (K-S) tests were carried out to assess normality of each variable. The homogeneity of variances were also assessed using an F-test to determine if variability within data sets was comparable. Providing these criteria were fulfilled, the ANOVA was applied (Appendix C).

Building/DIY-related and transport-associated groups showed no significance with any of the variables tested. This could have resulted from the relatively small numbers found in these groups. Results of the remaining two larger groups, household/commercial/industrial and general, were significantly related to land-use and road network. As data was normally distributed it was possible to apply a multiple range test to determine which specific variable categories differed significantly. Regarding land-use, the household/commercial/industrial items were recorded in significantly higher numbers in residential/industrial and industrial/commercial areas than open space. Although overall road network was found to be a significant variable for this litter group, the Sheffes test showed no individual road networks were significantly different. For general items, land-uses of residential, open space and residential/open space mix had significantly lower numbers than industrial/commercial areas. In this case some individual road networks were found to be significantly different, with 'A' graded road network areas having higher litter numbers than ungraded areas. The universal non-significant result between litter quantities and access may reflect a certain mobility of tipped items causing a spread away from point sources, preventing detection in the quantitative survey.

The litter groups with the most recordings, household/commercial/industrial and general, confirmed earlier results which reflected the significance of land-use (Table 4.4). For both litter groups, higher numbers were recorded for the industrial/commercial land-use areas than for open space. As such it seemed that the presence of fly-tipping could be detected using quantitative survey results, and that household/commercial/industrial items were the best indicator to reflect tipping due to their abundance.

River Physical Characteristics

Following the fly-tipping related sections in the site information form, were river physical characteristics; river profile, width, depth and pattern. Recordings in these categories in many respects reflected a site's position within the catchment. This is due to the natural progression of a river from its steep-sided narrow characteristics in upper catchment areas, with shallow waters, to the gently sloping, wide, deep river with faster moving waters in lower catchments. Some link would therefore be expected between these parameters. This hypothesis was tested by means of a correlation matrix (Table 4.5). Results showed clearly that all characteristics were correlated with the exception of river pattern. This is not a surprising result as river pattern not only reflects the position of a site in the catchment, but also the flow conditions at the time of sampling. From this it was concluded that in future surveys only one of the width, depth and profile parameters need be measured, as in reality they are all hydraulic variables and record the same information. Within the River Taff, testing for any relationship between litter abundance and these physical parameters would be pointless. If these characteristics did have any effect on the litter it would be swamped by the impact of changing positions of the site within the catchment, thus rendering any conclusion drawn invalid. Such details may be recorded in the future to enhance descriptive information for a site but would probably be of little use in statistical analyses.

Table 4.5. Correlation Matrix of River Physical Characteristics

	Correlation Coefficient	Profile		Width		Depth		Pattern	
		corr	prob	corr	prob	corr	prob	corr	prob
Profile	Pearson			.365	.005	.343	.007	.028	.424
	Spearman			.315	.013	.245	.043	-.065	.327
	Kendal			.289	.011	.210	.040	-.060	.326
Width	Pearson	.365	.005			.611	0.00	-.144	.160
	Spearman	.315	.013			.620	0.00	-.252	.039
	Kendal	.289	.011			.568	0.00	-.240	.036
Depth	Pearson	.343	.007	.611	0.00			-.217	.066
	Spearman	.245	.043	.620	0.00			-.333	.009
	Kendal	.210	.040	.568	0.00			-.303	.007
Pattern	Pearson	.028	.424	-.144	.160	-.217	.066		
	Spearman	-.065	.327	-.252	.039	-.333	.009		
	Kendal	-.060	.326	-.240	.036	-.303	.007		
Key: corr - correlation; prob - probability									

Vegetation and Stranding

Vegetation pattern was another characteristic recorded at each site, considered important due to its implications in stranding litter. The resulting "Christmas Tree" effect (Plate 3.2), a common phenomenon within the Taff catchment, was investigated to determine if significant differences were recorded in numbers of "stranding-susceptible" litter items with changes in vegetation density. Only litter items with physical characteristics considered susceptible to stranding were tested. These included all feminine hygiene products, all plastic sheeting, plastic bags, sweet papers and cloth/shoes. Initially these items were cross-tabulated with vegetation densities (Table 4.6). This tabulation immediately presented an obvious trend for most items tested; high item numbers at dense vegetation sites (A) decreasing in numbers towards the sparse vegetation (D). It should be noted at this point that vegetation category A had too few cases, only two, to be included in any statistical analyses, and as such was removed for further tests.

Table 4.6. Cross-tabulation of Vegetation Density with Litter Stranding

	Vegetation Type			
	A (Dense)	**B**	**C**	**D (Sparse)**
Count	2	34	46	18
Sanitary Tow. Mean	20	16.088	12.348	8.222
Panty Liner Mean	4	5.058	3.696	2.056
Tampon Mean	0.5	2.706	1.630	1.444
< 30 Sheeting Mean	9.5	8.676	7.978	6.167
30-60 Sheet. Mean	11.5	10.559	8.565	5.833
> 60 Sheeting Mean	7	9.529	6.609	3.722
Plastic Bag Mean	5.5	4.206	3.348	2.444
Sweet Paper Mean	5	7.441	9.021	7.722
Cloth/Shoe Mean	6	7.588	5.391	3.889

To test the significance of the relationships of these items with vegetation, an ANOVA was carried out providing test criteria were met (Appendix C). Those litter items found to be non-normally distributed were analysed using the comparable non-parametric Kruskal-Wallis test, (Appendix C). Results indicated that only sanitary towels and plastic sheeting > 60 cm were significantly distributed according to vegetation density at the $P <= 0.05$ probability level. Of these significant results, only sanitary towels were normally distributed. For this case it was therefore possible to apply a Sheffes multiple range test. Table 4.6 showed that sanitary towel numbers were significantly higher at sites with dense vegetation (B) than sparse vegetation (D). It is worth mentioning that many of the litter items tested were almost significant at the $P <= 0.05$ level, and that panty liners, tampons and plastic sheeting 30-60 cm were significant at the $P <= 0.1$ level, with plastic sheeting < 30 cm on the $P <= 0.1$

borderline. It appears that the groups with largest numbers (Table 4.6) were significant at higher probability levels. Plastic bag and sweet paper numbers showed absolutely no relationship to vegetation density. In general, the survey results suggested that vegetation density was a significant factor in determining accumulation of plastic and feminine hygiene items.

Sewage Inputs

The final section on the site information form (Appendix A7) addressed point-source inputs of sewage as indicated by the presence of a sewage pipe within or up to 50 m upstream of the survey site. Using a t-test, having tested for data normality, the importance of sewage pipe presence was tested in relation to quantities of sewage-derived items at surveyed sites and was found to be significant (Appendix C). However, it should be noted that the presence of a pipe in no way reflects its activity, and in many cases pipes may even have been non-functioning. This fact meant that a very obvious pattern would need to emerge to obtain statistically significant results under such circumstances.

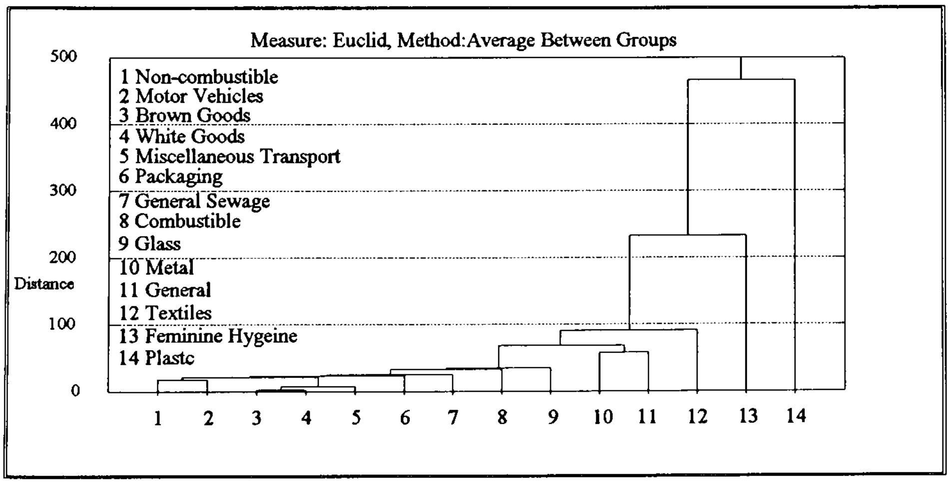
The sewage-derived group was then split into its two subgroups, feminine hygiene and general sewage items (Table 3.3). Sewage pipe proximity was highly significant for feminine hygiene items but not for general sewage items. It is possible that general sewage items were found in too few numbers to be significantly different. This result indicates that feminine hygiene products might be suitable sewage pollution indicators. It appeared that although the presence of feminine hygiene material was diverse throughout the catchment, actual quantities did show up sewage "hot spots". This may reflect a low level of mobility for these items away from their source or a constant input, and also demonstrates the importance of collecting quantitative data.

Cluster Analysis

In the pilot study (Chapter 3), pair-wise correlations between litter items were investigated. Such correlation matrices were not considered appropriate for this data set as the huge number of possible permutations would produce an unwieldy output which would be almost impossible to interpret. As a result, multivariate techniques were applied with the view that the increased size of the data set would overcome the problems encountered when these techniques were attempted during the pilot study.

Cluster analysis techniques were applied first to the data set, using the method outlined in Chapter 3. It is a technique used to show patterns in data sets, and is especially useful if little is known about trends within the data set. In this case, a split in the data was known to exist, between sewage and fly-tipping-derived wastes, and so the technique was simply applied to confirm this theory (Fig. 4.5). Cluster analysis gives no indication regarding the cause behind group linkages, it is merely a tool that allows data sets to be examined with the possibility of aiding the process of hypotheses formulation.

Figure 4.5. Cluster Analysis of Litter Groups for All Data



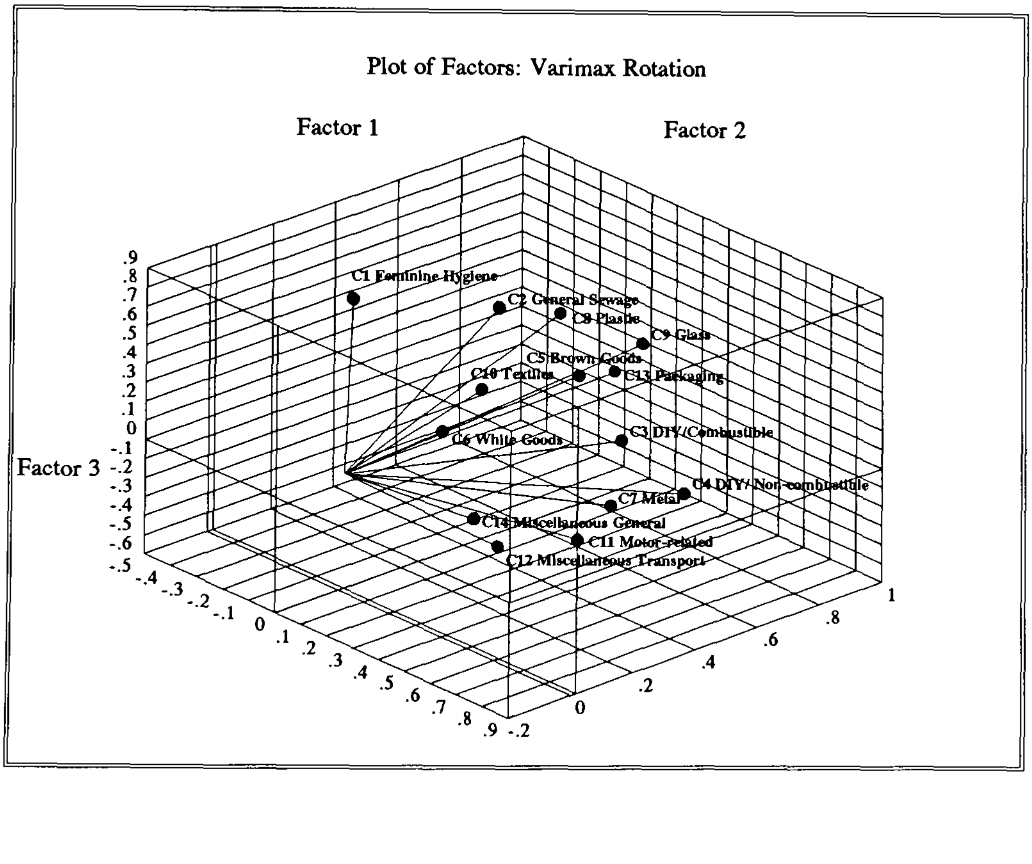
Fly-tipping items, generally found in small quantities at the same sites were closely linked near to the x-axis. However, general sewage items (No. 7, Fig. 4.5) were also found amongst these groups, probably due to the fact that only small numbers of items were found. In cluster analysis there was no similarity between feminine hygiene items (No. 13, Fig. 4.5) and general sewage (No. 7, Fig. 4.5). This may have been due to large differences in the quantities recorded. Most dissimilar from all the other groups were feminine hygiene items and plastics (No. 14, Fig. 4.5). These two groups, however, despite being found in high numbers, were not linked to one another, indicating that they were either not found at the same sites or that they differed in quantities at sites. The data (Appendix B) was then split into summer and winter results, and clusters produced for each. This split did not yield any additional information, and so was not pursued further.

Principal Component Analysis

Principal Component Analysis (PCA), another powerful pattern recognition tool was then applied to the data set (Appendix B). This procedure successfully identified factors that accounted for the major variations within the data set, with factor one accounting for the greatest variation within the data set, followed by factor two and then factor three and so on. Analysis of the entire data set provided three main factors which accounted for 57.4% of the overall variance within the data set (Appendix C). A varimax rotation was then carried out in accordance with common PCA practice in cases with more than two factors, to simplify interpretation. Using PCA, the underlying dimensions of a data set may be defined in several ways, there is no one answer. Rotations simply help to produce the most meaningful data representations to allow interpretation. A basic outline of this approach was discussed in Chapter 3.

Initially, the entire data set was analysed and plotted for the first three factors (Fig. 4.6). A plot of variable loadings for the three factors produced one very distinctive separation in the variables, between feminine hygiene items and tipped waste categories. The feminine hygiene group was overwhelmingly important in factor 3, followed by general sewage items. This confirmed earlier suggestions regarding the suitability of feminine hygiene items as sewage contamination indicators. On the strength of the importance of these groups in determining factor 3, it was named the sewage factor. Despite forming the most obvious grouping, factor 3 was the least important factor in determining overall variation in the data set. Factors 1 and 2, both seemed to relate to tipping wastes, but when examined more closely could be further split into two separate groupings. Those items most important in factor 1, tended to be groups ordinarily related to household tipping, i.e. plastic, textiles, brown and white goods, whereas those items important in determining factor 2 could potentially be industrial/commercial in origin, i.e. motor vehicles, metal and miscellaneous items.

Figure 4.6. Principal Component Analysis for Litter Groups (Summer and Winter)



These factors were therefore both considered to be fly-tipping factors, but with factor 1 possibly relating more to household tipping, and factor 2 relating to other tipping forms. Thus factors 1 and 2 were labelled more tentatively due to the more diffuse groups formed.

The same data was then split into summer and winter results, and analysed in the same manner. Quite varied results were produced, especially in the summer survey results, which differed markedly from the overall output (Fig. 4.7). Both retained the primary split between feminine hygiene items and tipped waste, but variations in positions of the tipped waste groups were considerable, especially when if summer and overall results were compared (Figs. 4.6 & 4.7). Winter survey results however, produced much clearer groupings (Fig. 4.8). Feminine hygiene and general sewage items were grouped together in winter survey results, forming an even more distinct sewage factor than for the combined data set, one which was distinct from other waste categories. Factors 1 and 2 could also be split into more clearly defined groups in the winter survey. Factor 1, the factor accounting for the most variation in the data, changed in composition between summer and winter. Summer results produced less distinct groups for the two tipping types. However, some of the previously labelled commercial/industrial tipping groups were still dominant in the first factor, and household waste groups changed to be more important in the second factor. This situation contrasted that shown by the winter results, and could indicate a change in the predominance of different tipping types with season.

Overall results (Appendix C) seem to indicate that variation in site litter items can be identified through 3 factors; one definite sewage factor (3), and two tipping factors, interpreted as household (1) and industrial/commercial tipping (2). Seasonal surveys (Figs. 4.7 & 4.8) showed that, although fewer items were found during winter assessments, their distribution was such that influencing factors could be more easily determined. This may be sufficient reason to recommend that future surveys be carried out during winter. The significant increases in textiles and miscellaneous items during the winter, contrary to trends in other groups, was considered in this analysis. However, seasonal plots did not lead to any further understanding of this phenomenon, and was therefore left unexplained.

Site data was plotted in relation to the three factors, first for the overall data set (Fig. 4.9), and then for summer (Fig. 4.10) and winter (Fig. 4.11) splits. A certain amount of consistency was demonstrated by sites that were heavily influenced the three factors. Sites 16, 20 and 48 (Appendix B), for example, were plotted in very similar positions for both summer and winter surveys indicating a certain amount of uniformity in the quantities and composition of litter found at these sites on both occasions (Fig. 4.9). The plots indicated that sites 15, 32, and 33 were important in relation to factor 3, the sewage factor. When cross-referenced with site information, all these sites were recorded as having large quantities of sewage-derived material and actually contained sewage pipes within them, confirming the appropriate naming of this factor.

A predominance of sites numbered between thirty and forty were shown as being important in relation to sewage (Fig. 4.9). Interestingly these were sites on the River Cynon, the tributary highlighted earlier as having the highest sewage composition within the catchment.

Figure 4.7. Principal Component Analysis for Summer Results

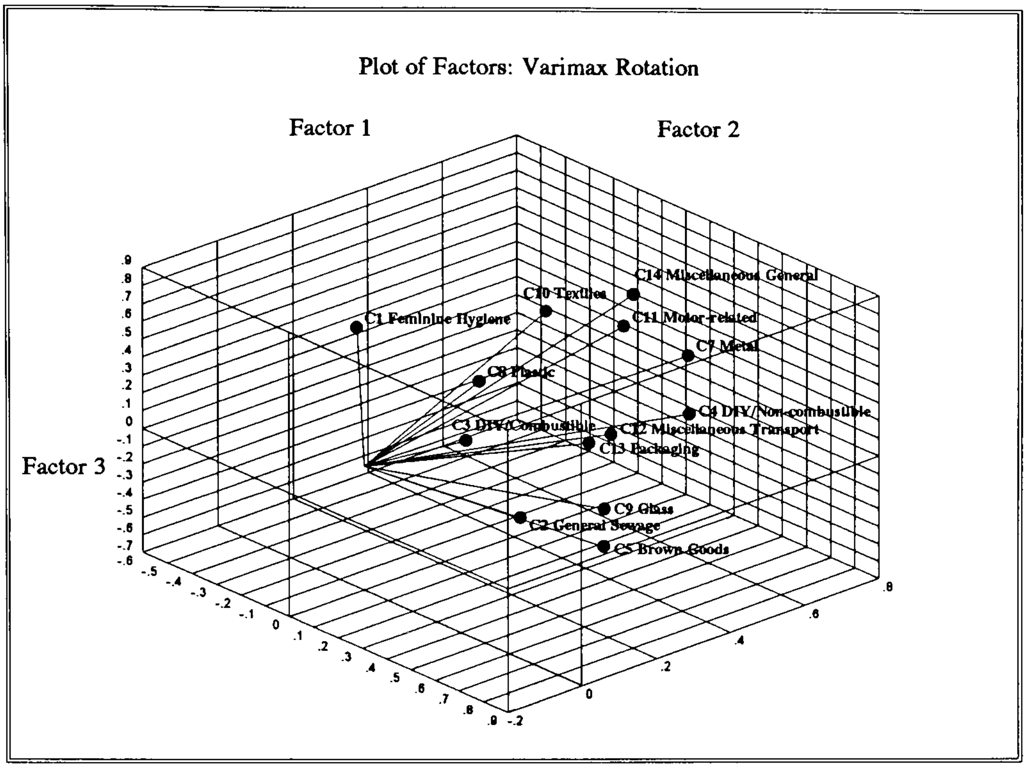


Figure 4.8. Principal Component Analysis for Winter Results

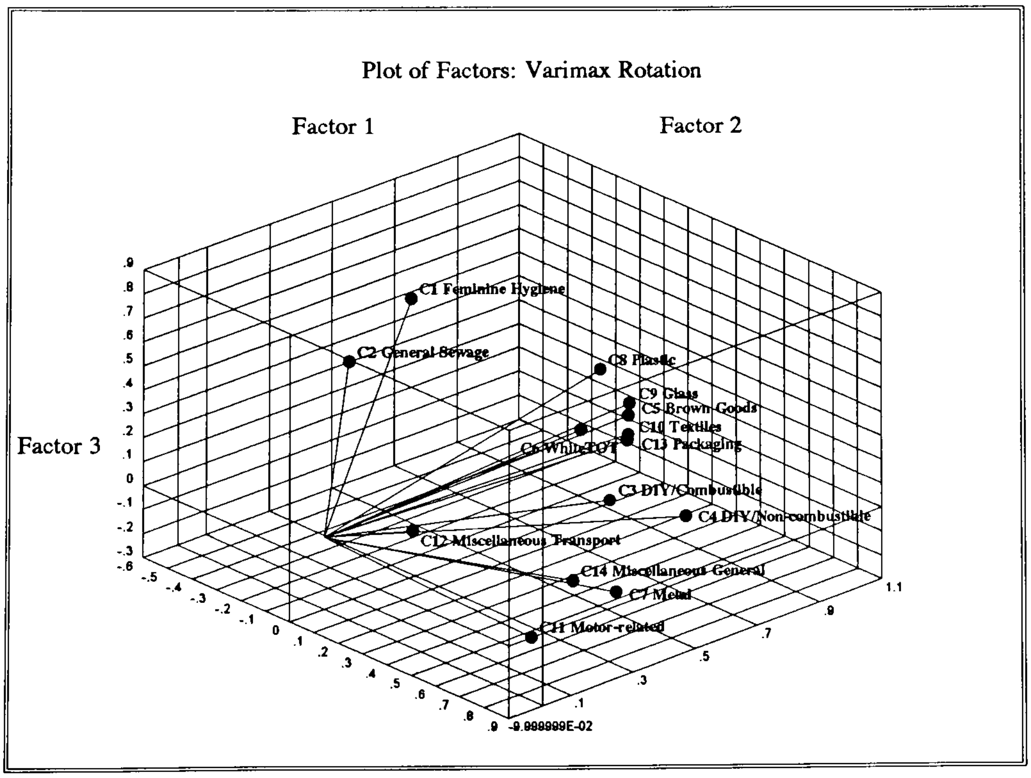
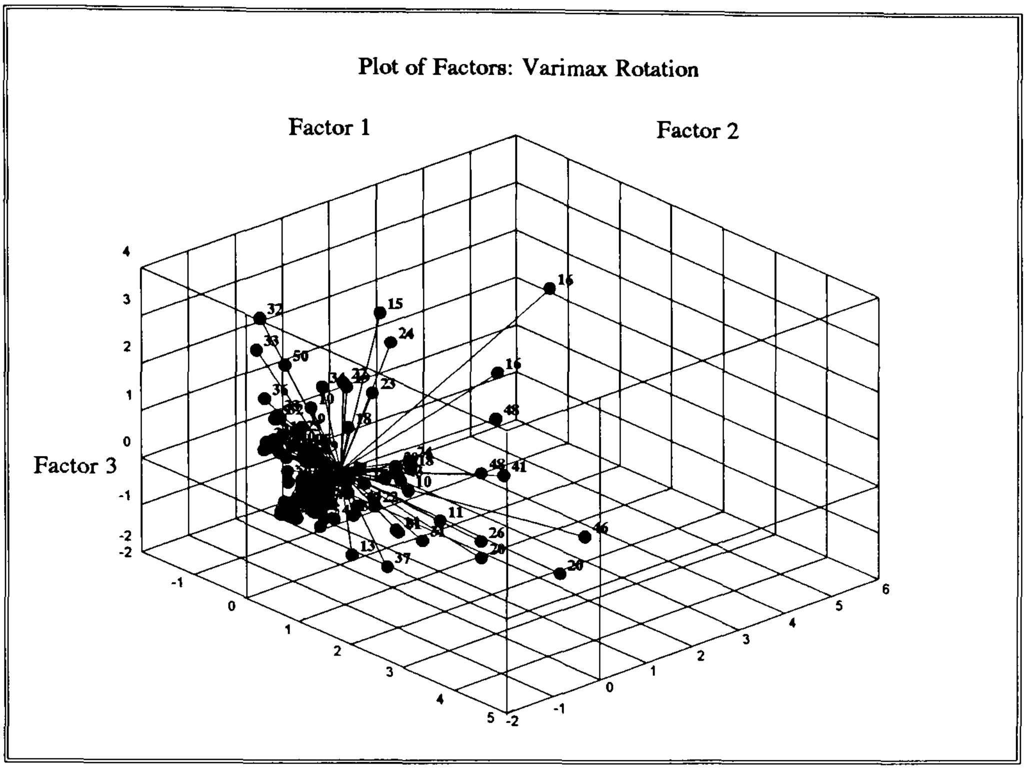


Figure 4.9. PCA of Sites (Summer and Winter Results)



The situation regarding the remaining two fly-tipping factors was, however, a little more complicated. For the overall results (Appendix B), site 16 (Rhydyfelin) appeared to be an important site in relation to factor 1, this remained the case in winter results, but not for the summer (Fig 4.10). Likewise, site 20 (Taffs Well) was recorded as an important site in relation to factor 2 for the overall (Fig. 4.9) and winter (Fig. 4.11) but not in the summer. Summer plots showed these sites to have almost swapped positions, i.e. site 16 had become important in relation to factor 2 and site 20 important in relation to factor 1. This pattern, like the litter groups, reflected a seasonal change in the importance of different types of fly-tipping.

In conclusion, PCA proved itself to be a useful tool for determining underlying trends in the Taff catchment data set. Its application is, however, limited to data sets with only few zero recordings and therefore could not be used for analysis of catchments with low litter recordings.

Figure 4.10. PCA of Sites (Summer Results)

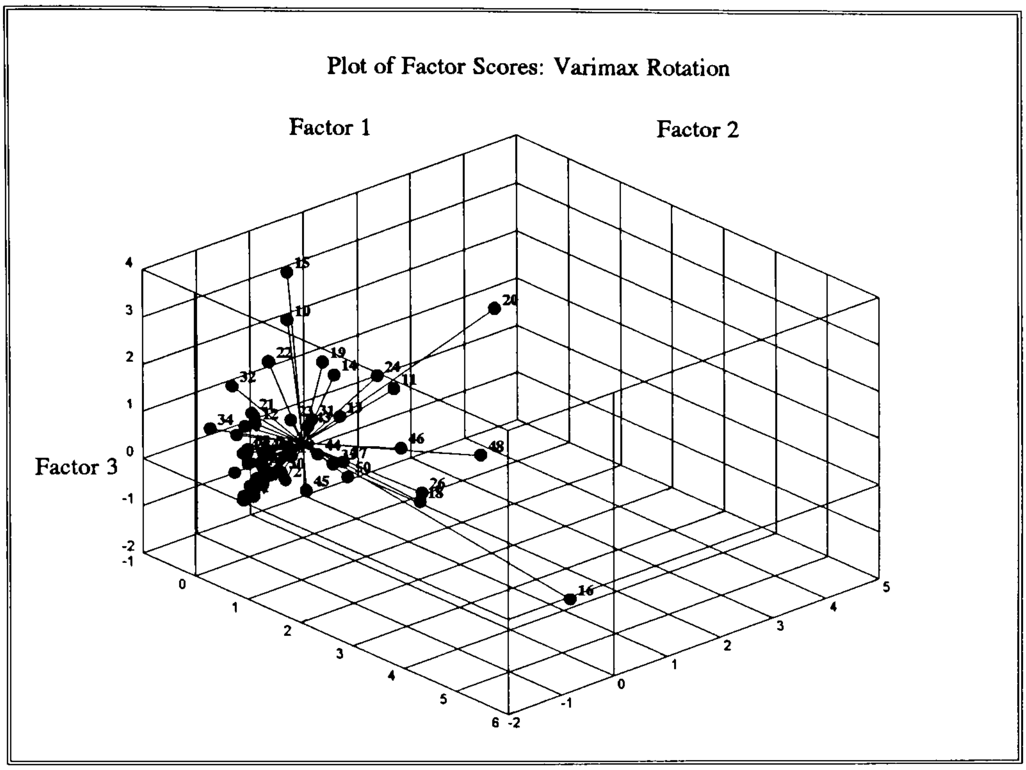
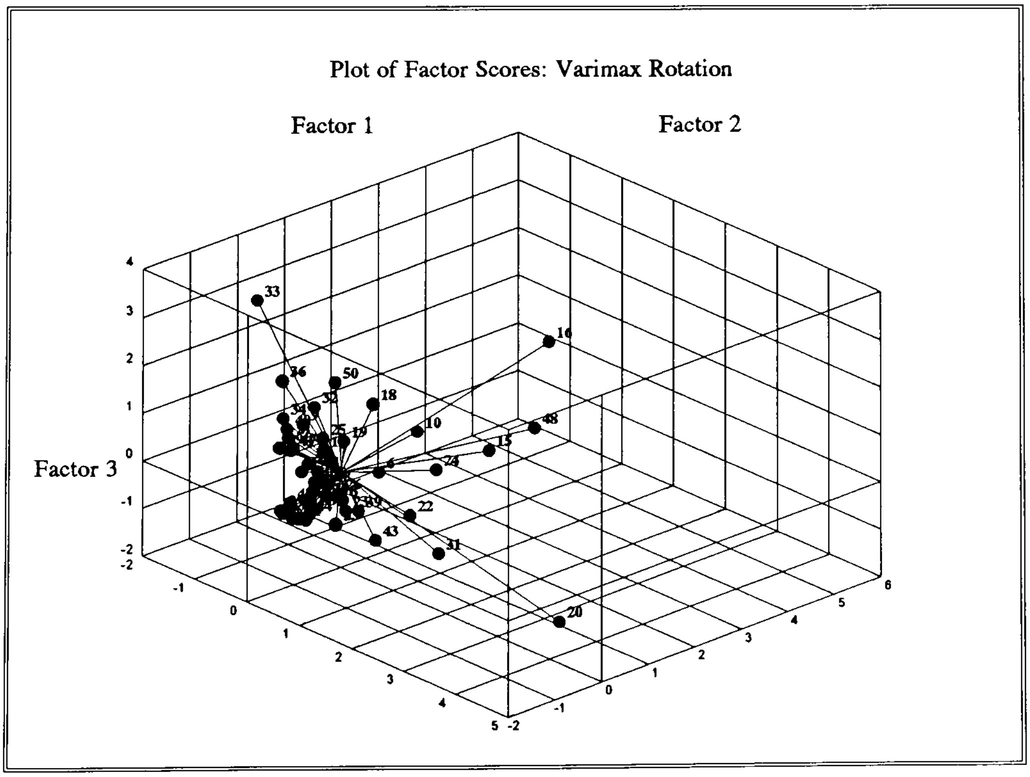


Figure 4.11. PCA of Sites (Winter Results)



E. Lyn Catchment

Litter Composition

The E. Lyn, a much smaller catchment than the Taff (Chapter 3) was only assessed at twenty sites. The total litter recorded for both summer and winter surveys was 147 items, meaning approximately 25 items were found per hundred metres bank length. Plastics predominated once again, forming 70% of total litter, but the remaining composition was quite different from the Taff (Fig 4.12). Sewage-derived items constituted only 2% of the total (1% feminine hygiene, 1% general sewage). Such a reduction was not unexpected due to lack of urbanisation along the river and absence of many SWOs (Chapter 2). High proportions of glass, miscellaneous and metal items were also a feature of these results. Four litter groups, namely brown goods, white goods, motor and transport associated, all tipping-related litter groups, were completely absent from the catchment.

Seasonal Litter Variations

A comparison of summer and winter results indicated an opposite trend in seasonal variation to that demonstrated by the Taff (Fig 4.13). Paired t-tests were again applied to determine the significance of these changes (Appendix C). Total amounts of litter found increased significantly from summer (42) to winter (105) at the $P <= 0.05$ level. With the exception of sewage items and DIY non-combustibles, both of which were absent during the winter, most of the groups showed increases in litter numbers in the winter. Whilst, little can be said regarding the particular groups, as such low numbers were recorded when they were present, considerable increases were recorded for both plastic and miscellaneous groups in the winter, of which only the miscellaneous group was statistically significant. The increase in miscellaneous items may once again have resulted from increased litter fragmentation during winter.

Figure 4.12. E. Lyn Litter Composition

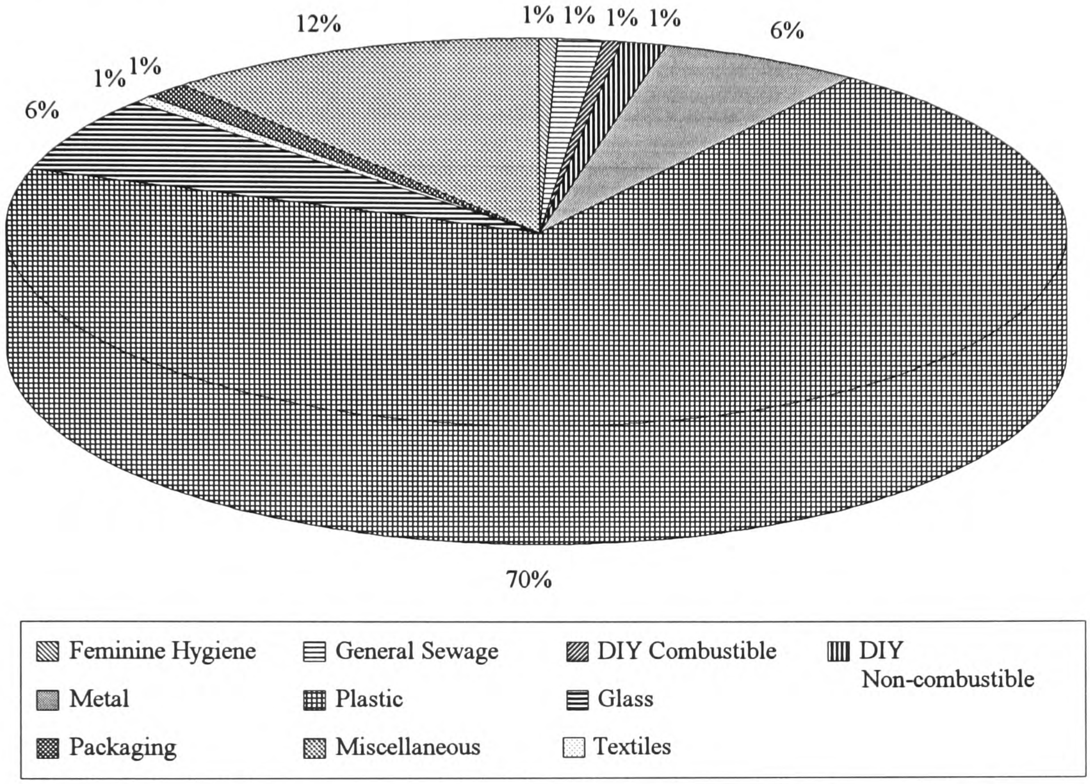
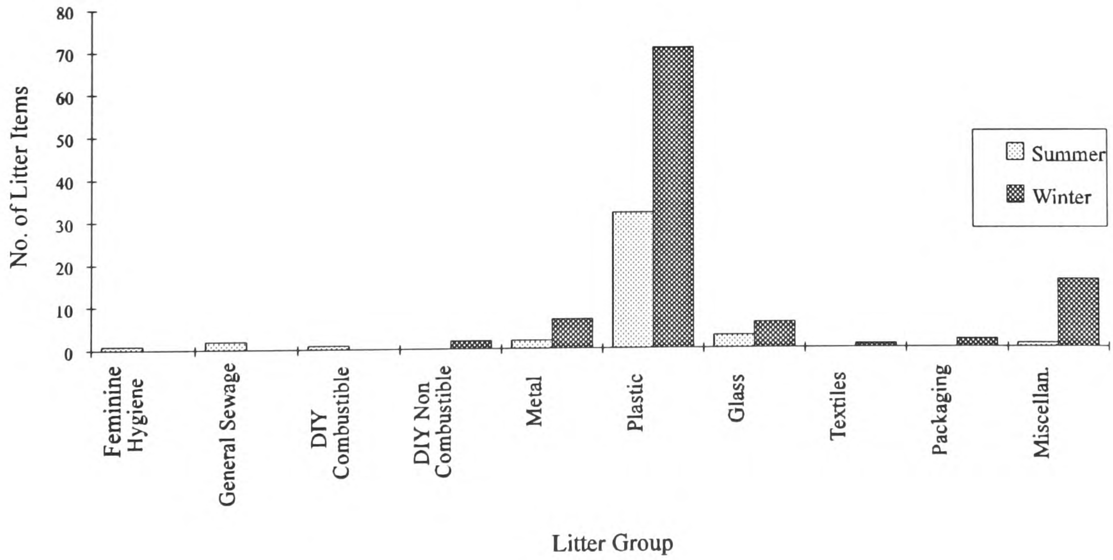


Figure 4.13. Seasonal Composition of Litter on the E. Lyn



The increase in plastics is rather more difficult to explain. The overall increase of litter in the catchment during the winter tends to discount the possibility of tourism being an important input source. As the entire Lyn catchment falls within the Exmoor National Park, with a considerably increased summer population, visitor discards might be expected to be a potential input. This does not however appear to be the case.

Vegetation and Stranding

The general lack of litter within the E. Lyn catchment made many of the analyses carried out on the Taff impossible to apply. Cross tabulation of litter with vegetation density was attempted, as a variety of vegetation types were recorded, as well as a number of litter types susceptible to stranding (Table 4.7). Results, however, showed no trend, possibly due to low item numbers found. On this basis further statistical analysis were abandoned.

Table 4.7. Cross-tabulation of Vegetation Density with Litter Stranding on the E. Lyn

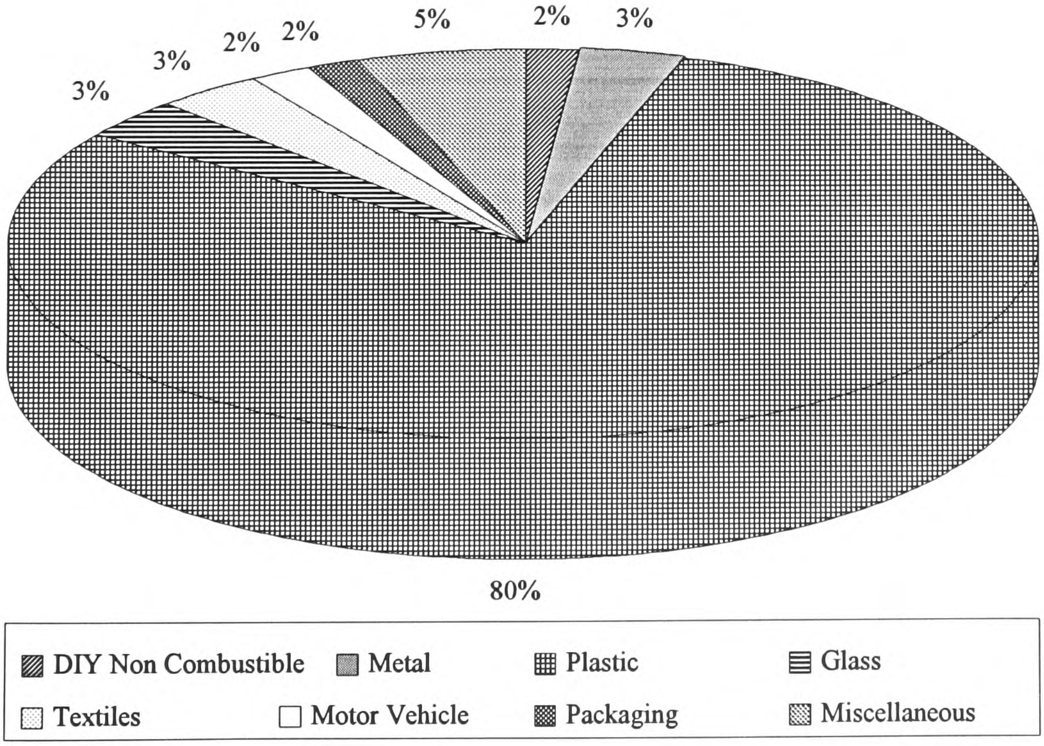
	Vegetation Type			
	A (Dense)	B	C	D (Sparse)
Count	8	16	12	4
Sanitary Tow. Mean	0	0.063	0	0
Panty Liner Mean	0	0	0	0
Tampon Mean	0	0	0	0
<30 Sheeting Mean	0	0.875	0	0
30-60 Sheet. Mean	0.25	0.438	0.667	0
> 60 Sheeting Mean	0.125	0.063	0.25	0
Plastic Bag Mean	0.125	0.313	0.008	0
Sweet Paper Mean	0.5	0.375	0.25	3.5
Cloth/Shoe Mean	0	0	0.008	0

Avill Catchment

Litter Composition

The Avill was the smallest of the three catchments assessed (53 km²), and also turned out to be the least littered. During both summer and winter surveys of the catchment's twenty sites, only 58 items were found, an average of approximately ten items per hundred metres. Of these items, plastics constituted 80%, the remaining groups being almost equally represented, with only slightly higher miscellaneous numbers (Fig. 4.14). Sewage-derived material was completely absent, along with DIY combustible, brown and white goods, and transport-related items. Absence of sewage-derived material was probably due to low catchment urbanisation and few riverine SWOs. The other groups not found within the catchment consisted largely of those considered to be fly-tipping-related wastes. Therefore, fly-tipping did not appear to be a problem on the Avill.

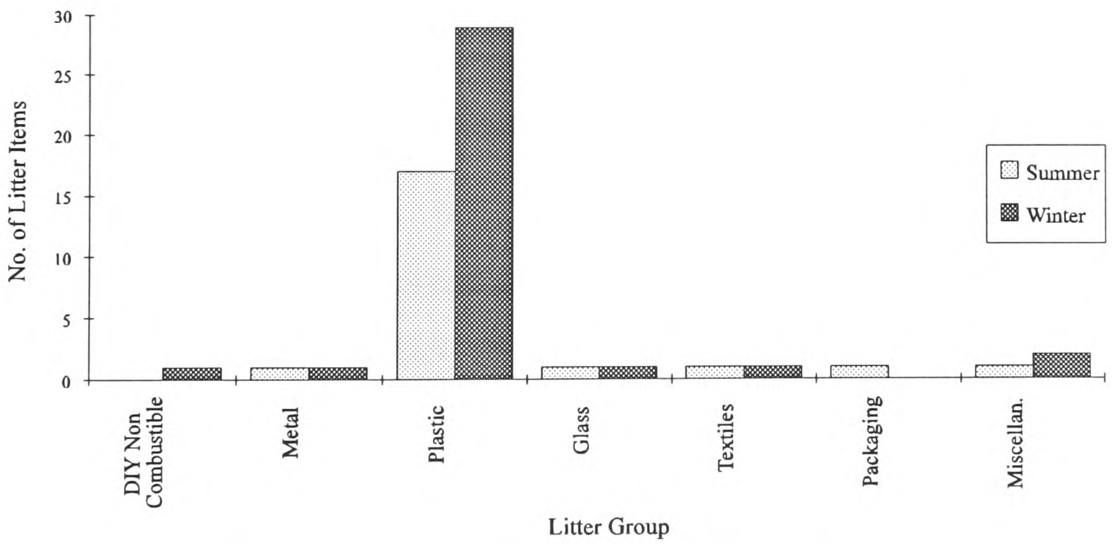
Figure 4.14. River Avill Litter Composition



Seasonal Litter Variations

A comparison of summer and winter results showed an increase in items from summer (22) to winter (36), the same pattern as the E. Lyn (Fig. 4.15) but did not prove significant when a paired t-test was applied (Appendix C). Litter quantities found were so small that little significance could be given to most of the increases. The overall increase in winter, was mainly due to a rise in plastic and miscellaneous items, but neither were significant at the $P <= 0.05$ level. Results (Appendix C) suggest that within the Avill catchment, as with the E. Lyn, tourism and visitor discards do not form significant river litter contribution sources.

Figure 4.15. Seasonal Composition of Litter on River Avill



Beyond the paired t-tests, statistical analyses were not considered feasible due to data limitations caused by the low number of items recorded. No further interpretation of these results was therefore possible.

Catchment Comparisons and Conclusions

The Taff, E. Lyn and Avill differed greatly in litter quantities and types within the catchments. Litter levels on the Taff were incomparably higher than the E. Lyn and Avill. The contrast between catchments is largely due to differing patterns of urbanisation and sewage treatment. Linear development along the Taff's tributaries and main river have led to misuse of the river as an open sewer and general dumping ground. The higher population surrounding the river puts a great strain on the sewage disposal system. This system runs along the valley floor, i.e. down the river, on its journey to treatment works. To cope with the significant inputs and also heavy rainfall, pressure release systems are necessary along its length. It is these SWOs, not present in any number in the E. Lyn and Avill, that contribute the high sewage element to litter on the Taff. In parallel the Taff suffers from a corridor tipping problem due to much of the river either having direct vehicular access or potential for over-the-boundary tipping. Neither the E. Lyn or Avill are urbanised to a level likely to be affected by tipping. It may therefore be concluded that the Taff catchment is rather atypical in its litter problem, rendering a worse case scenario due to intense linear development.

The E. Lyn and Avill have more comparable patterns of catchment urbanisation. Both have only minimal littering and no real sewage contamination. The higher levels of urbanisation and tourism on the E. Lyn may well account for slightly increased littering within the catchment. Both catchments have greater amounts of litter in the winter, especially plastic sheeting. This was rather difficult to explain unless it resulted from certain farming practices in these areas.

In conclusion, the baseline survey was effective in quantitatively assessing riverine litter in the surveyed catchments, although interpretation of data was limited for catchments with minimal littering.

CHAPTER 5

FLY-TIPPING

Introduction

Fly-tipping is a product of modern society; created by increasing materialism and demands for disposable products with built in obsolescence. The elevated waste levels, synonymous with such goods, pose considerable disposal problems, culminating in increased illegal tipping activity. Resulting deposits not only cause aesthetic offence, but may also be hazardous and extremely costly to remove.

Fly-tipping was initially defined by the London-Wide Initiative on Fly-Tipping Working Party (LIFT) as "the unlawful deposit of waste on land without the landowner's consent" (LIFT, 1984, p6). More recently, Coggins et al (1991, p3) refined the definition to distinguish it from casual littering "in that it is a ***deliberate*** dumping of often bulky waste items following a conscious decision to dispose of this waste".

Fly-tipping is not a new problem. Continual illicit dumping of bulky refuse in certain urban areas in the 1960s became such a problem that Civic Amenity sites were introduced, under the Civic Amenities Act in 1975 (Civic Trust, 1967). These sites were instigated to allow householders free disposal of unwanted bulky refuse, and have to a large extent been successful, reflected in a trebling in waste quantities received at these sites since their formation (Coggins et al, 1989). In later work, Coggins et al (1991) showed using national tonnage data, that Civic Amenity sites received greater than 25% of all household waste, and suggested that fly-tipping resulted in areas with ineffective services, or where public awareness of facilities was low.

Despite the success of Civic Amenity sites, fly-tipping continued to be a problem in many areas. LIFT's (1984) pioneering assessment of fly-tipping in the London area, indicated that in 1983, the total quantity of fly-tipped waste in London was in excess of one million tonnes, the removal of which would cost tens of millions of pounds. The study also identified 10 sites in the London area, each having in excess of 10,000 tonnes of waste, despite adequate provision of facilities in many areas. To understand the problem further, the main offending groups were characterised, and found to be of four basic types; (1) carriers of waste for profit, (2) commercial and industrial firms disposing of their own waste, (3) residents disposing of household items, and (4) travellers. Within the London area the greatest single cause of tipping was from waste carriers, who profited from the substantial financial rewards of large-scale illegal dumping. It was suggested that the costly waste disposal options available to commercial and industrial firms frequently resulted in them opting for a cheaper alternative, i.e. dumping the material themselves, or paying an organised criminal fly-tipper (LIFT, 1984).

Public Perception

Public opinion regarding fly-tipping and general littering is constantly changing. A Gallop survey first carried out in 1978, and repeated in 1983, showed a marked hardening of attitudes towards tipping (INCPEN, 1983). Overall, people surveyed felt that the litter problem was worsening. When asked to suggest improvement measures, a noticeable swing was seen, away from the penalty system and towards proactive measures such as increasing numbers of road sweepers, litter bins, and improving public awareness. Midland Environment Limited (MEL, 1989), questioned the effectiveness of such action, and suggested that if used in isolation, the impact would be minimal. Alternatively, they recommended measures should be taken in combination with active public participation in clean-ups, backed by publicity stressing both social and legal consequences of littering and dumping.

MEL (1989) also introduced the concept that increasing man-made influences were negatively correlated to positive environmental attitudes, thereby suggesting that fly-tipping would impose a greater detraction in the beauty of a rural area than an urban one. This theory was confirmed in later work (MEL, 1991) which stated that fly-tipping occurrence was inversely related to reported incidents. Areas with recorded higher levels of tipping were reported less often than those with lower tipping levels. Obtrusiveness, was suggested as an explanation for this situation, i.e. fly-tipping is less obtrusive in areas of poor aesthetic quality, as it becomes part of the "general disamenity".

"For a given level of fly-tipping, different residents will have a different perception of the significance of the problem" (MEL, 1991, p4). Affluent people with greater mobility and increased leisure time showed a higher rate of reported tipping incidents than in less affluent communities. This situation creates a problem for Local Authorities in the way they should tackle fly-tipping incidents and respond to public complaints. If an Authority prioritises clean-up activities in those areas about which they have received most complaints, they may not necessarily be dealing with the major problem areas, just those areas with the most vociferous residents.

Legislation and Local Authority Actions

The 1970s saw the introduction of Civic Amenity sites, culminating in successful reductions of domestic dumping incidents. However, the supposed benefits of this success went largely unnoticed due to a counteracting rise in commercial tipping activity, thought due to increasing trade waste disposal costs.

During the 1980s preliminary moves were made to tighten legislation regarding fly-tipping. However, it was not until the 1990s with Margaret Thatcher's promotion of the "Clean Nineties Campaign", that tougher measures were finally introduced through the "Duty of Care" legislation in the Environmental Protection Act (HMSO, 1990). Generators, carriers and waste disposers then came under obligation to ensure the safe and environmentally acceptable disposal of waste. In addition, stringent registration for waste carriers was introduced, together with more substantial fines to penalise waste carriers dumping on unauthorised land.

Regardless of improvements in legislation, the problem of enforcement still remains. Few realistic deterrents exist for potential tippers due to the minimal chance of prosecution as offenders must be "caught in the act". With relatively few prosecutions, Local Authorities often resort to making examples of the few cases that are successfully brought to court, by the imposition of large fines, in the hope of deterring potential tippers.

Local Authorities usually deal with litter and tipping by two general means; "proactive" preventative measures may be taken by initiating litter prevention schemes and environmental education programmes, or alternatively, "reactive" after the event, clearances in response to complaints or routine patrolling of problem areas. Most Authorities will implement a combination of both these approaches, but few appear to have attempted addressing the route of the problem - the source.

Eldridge (1985, p47), when speaking for the Tidy Britain Group, confirmed the importance of understanding the sources of tipped material in order to successfully manage them, "Since litter is dynamic, it is necessary to identify the source of litter, and of the debris and rubbish that is tipped or dumped. In order to prevent litter, sources are more important than black spots - though black spots must be cleared up as one of the main attitudes we have to contend with is that it is OK to dump or litter if there is already an accumulation of litter or rubbish there".

Urban Fly-tipping Methodologies

Despite the widespread nature of the problem, very little work has been undertaken to investigate fly-tipping specifically. A propensity of work exists in other areas of litter monitoring, e.g. marine and urban (Dixon & Dixon, 1981; Vauk & Schrey, 1987; Ashworth, 1989; Finnie, 1973), but to date LIFT (1984) and Coggins et al's (1991) work on monitoring fly-tipping constitute the only major studies in this area.

Coggins et al (1991), initially developed a fly-tipping waste classification scheme, devised to inter-link with current research on Civic Amenity sites and to incorporate information on waste origins. Fly-tipping waste was classified as being bulky in nature, and consisting of four principal groups: garden waste, bulky Do-It-Yourself waste, bulky household waste and ordinary household waste. Differentiation between domestic and commercial waste origins was found problematical in some cases because of the material types concerned. For example, "garden waste could be domestic or from landscape gardeners; motor-related waste could be from a DIY motorist or a commercial car mechanic" (Coggins, 1991, p4). Often the only means of differentiation is consideration of waste quantities involved. Waste constituting a fly-tipping problem was defined in relation to quantity, e.g. greater than one sack-equivalent (100 litres) the typical plastic sack volume.

Coggins et al (1991) defined the main locational characteristics of fly-tipping as accessibility and attractability. Although tipping may occur in both rural and urban areas, sites susceptible to fly-tipping were noted to be linked with vehicular access, or where waste disposal could be made over property boundaries. Dumping related to vehicular access usually occurred at the minimum distance possible from the vehicle.

Fly-tipping not requiring vehicular transportation may also occur if easy access can be gained to areas by foot, such as derelict land and garage blocks. Boundary-associated "over the fence" tipping was prevalent on vacant land, open fields and industrial sites. Particularly problematical in urban areas was tipping associated with railway lines bordered by houses with gardens.

Attractability was considered important based on the noted frequency of tipping at derelict and untidy areas with little security or poor boundary markers. A phenomenon of "waste attracts further waste" (Coggins et al, 1991, p6) was also established for these sites. In such cases, previous tipping led others to believe further additions were acceptable and that, in largely tipped areas, the detection of any one offender would be unlikely. Attractability may also be present in the form of seclusion from public view, especially at times such as evenings and weekends when dumping is most likely to occur.

Coggins et al (1991) concentrated their studies on monitoring two known fly-tipping sites with time, one urban, and one rural. Information on waste disposal facilities in each area was first collected, recording exact positions of facilities and types of waste handled, etc. Data on fly-tipping site locations were collected together with accessibility and attractability ratings based on land uses and road network density. Assessments were then made regarding the waste dumped, i.e. category, type, volume, source etc. This approach was being developed in parallel with Midland Environment Limited (MEL, 1991) who were following a similar methodology, but with emphasis on types and quantities of waste and the prevalence of tipping in a range of sites. Although results from these studies were not discussed in Coggins et al's (1991) work, it was a stated aim that a combination of both approaches would culminate in draft guidance notes for Local Authorities to help deal with fly-tipping incidents.

Corridor Surveys

MEL (1991) recognised that "linear strips or 'corridors' of land often associated with transport systems, were particularly vulnerable to fly-tipping; four categories being identified: railways, canals, rivers and motorways" (MEL, 1991, p34). The higher proportions of commercial waste documented along rivers and canals in comparison with other sites surveyed resulted from the common practice of situating factories and commercial premises in such areas.

Preliminary observations indicated corridor-associated tipping was a significant problem within the Taff catchment. River bank sites with vehicular access, often provided by disused tramways, close to urban centres, but with enough seclusion to prevent detection, were regularly used as tipping sites. Over the fence, boundary tipping was surprisingly common in areas where houses border the river. Bulky wastes were often disposed of over property boundaries onto the river bank; out of sight of the residents, but still within metres of their land.

To date no work has been carried out specifically addressing the fly-tipping problem in relation to rivers, even though tipping along river corridors constitutes a significant potential litter source. The scale of tipping at many sites, together with the possibility of large-scale downstream movement of dumped material within the catchment, necessitated a better understanding of fly-tipping site processes. Information was needed regarding types of material, input rates, quantities dumped, and movement within and out of the site following deposition. To gain this information a case study was undertaken of one site typical of many within the Taff catchment that was accessible by vehicle or by any member of the public on foot.

Fly-tipping Case Study

Site Selection

Knowledge of fly-tipping "black spots" was gained during the Taff catchment baseline surveys. The site at Penywaun (SN 979 049) was chosen from many potential sites because of its size, accessibility, general lack of camouflaging vegetation, new inputs, and recent history. The tipping site was well known to the Local Authority as a problem area, and was the subject of numerous resident complaints. These protests resulted in a large scale clearance operation being carried out by Employment Action, on request of Cynon Valley Council at the onset of the monitoring programme. Material removed from the site was enough to fill (volume capacity) seventeen, three tonne capacity lorries. In addition to clearing the area, attempts were made to prevent future tipping by means of a natural barricade at the site's access point. Young trees were planted along the bank through which hawthorn cuttings were interwoven (pledging) to form a significant obstruction to potential tippers.

In view of the persistence of fly-tipping in established areas (Coggins et al, 1991) such preventative measures were not regarded as long-term solutions, but rather provided a short-term respite. On the basis of this assumption, monitoring was initiated following the clearance, taking full advantage of the cleared area.

Method

Due to the new and pioneering nature of this work, a methodology had to be developed to gain details of type, quantities and frequency of waste dumped, together with an analysis of movement patterns following deposition. This was achieved by a combination of checklist (Appendix A7) and photo-log monitoring. Identical checklists to the baseline surveys were used in this study, as it was specifically devised to accommodate fly-tipping as well as baseline assessments.

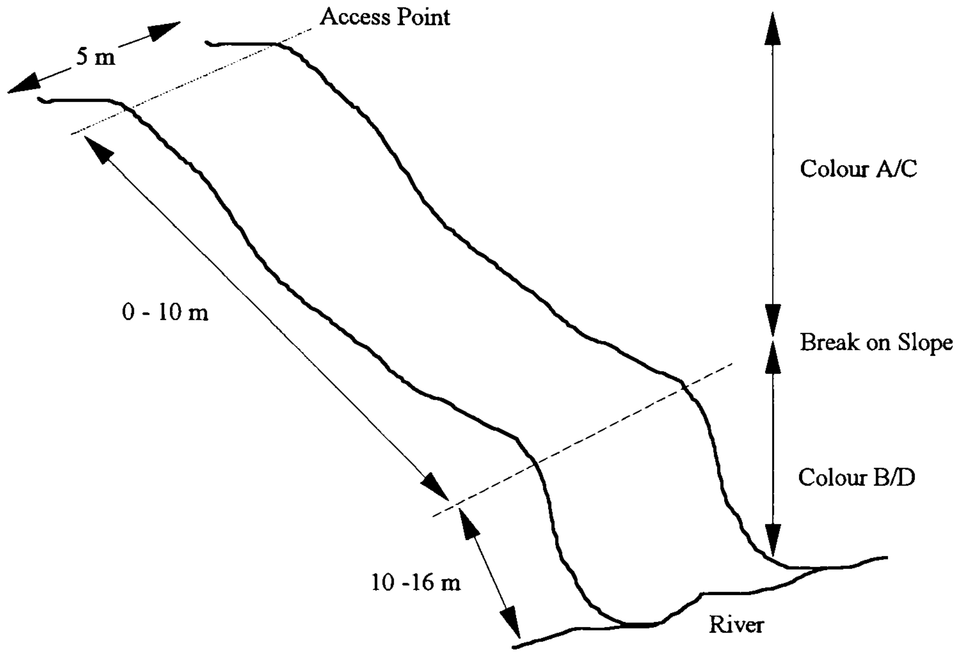
Checklist Monitoring

For checklist monitoring, a study area was marked out using a series of tapes and markers. A tape was extended the length of the bank and placed in the centre of the tipped area. Distances of 2.5 m were measured to each side of the tape, and 'flag' markers were placed to outline the 5 m belt transect boundaries (Fig 5.1). The established study area was then split into two sections at the natural break in slope, occurring at 10 m from the top of the river bank, and extending 6 m below the break. Within each of these areas all items greater than 5 cm in diameter were recorded. On the upper slope items were marked with one paint colour (Colour A), whilst those on the lower slope were painted a contrasting colour (Colour B). Movements of particular items from upper to lower slopes could then be easily spotted, and new contributions would be obvious. This initial monitoring was carried out at 'Time 1' (T1). The procedure was then repeated a second time after a five month period (T2), using two new marker colours (C upper slope, D lower slope) in conjunction with monitoring of previously sprayed items. One further assessment was undertaken following another five month interval (T3), this time recording the presence and position of previously sprayed items and any new contributions. Long sampling periods were applied to allow a reasonable amount of activity to occur at the site before re-spraying. More frequent monitoring would have required a more complex marking system. This was felt unnecessary as the study was devised to show long-term input and output of items in the site.

Photo-log Monitoring

An additional recording method, particularly useful for monitoring movements of larger items was also attempted during this study. Site photo-logs were taken regularly from a fixed point providing a visual documentary of inputs and movements with time by a process of overlaying images. This approach allowed more detailed knowledge of short-term movements to be gained within the site. Although the case study was undertaken over the period of one year, photo-logs were abandoned during the summer months due to interference from seasonal vegetation growth.

Figure 5.1. Fly-tipping Assessment Site Plan



Results and Discussion

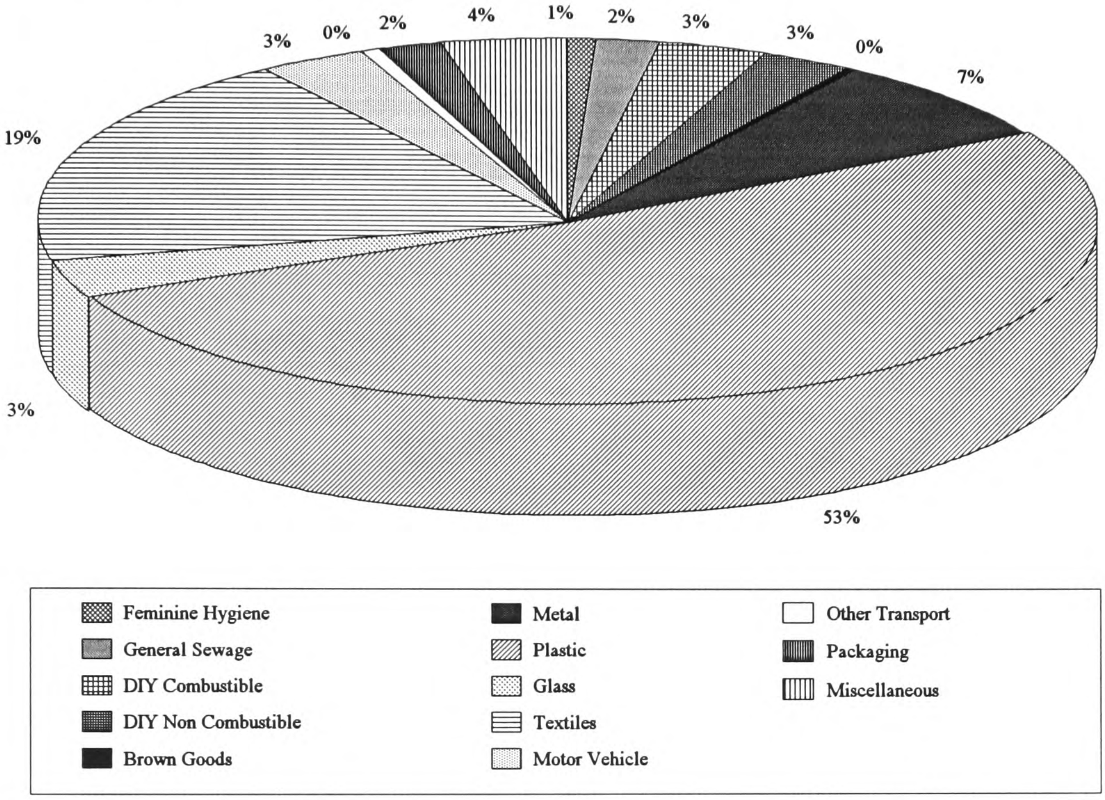
Checklist Assessment

The fly-tipping assessment results provided valid insights into the dynamics of a riverine fly-tipped site. However, it must be stressed that the study was applied as much to develop and refine assessment techniques, as to gain information. As such it is important to be cautious when discussing the results due to the limitations of a one site study.

Results were initially analysed to show overall site composition at the end of the monitoring period (Fig. 5.2). Over half of the items recorded were household/commercial/industrial plastics, of which 53.6 % were plastic sheeting and bags. Such high proportions of polyethylene sheeting could indicate fly-tipping sites as a major point-source contributor of plastics. This result could have great significance in the Taff catchment, as plastic sheeting was the largest single component of litter found during the baseline survey (Chapter 4). Of the remaining plastic, a noticeably high proportion was sweet papers (23.8 % of total plastics). These were noted to have originated mainly from bags of dumped domestic waste, the contents of which eventually emptied on to the site. Following plastics, textiles were the next largest category, composed of 73.4 % cloth/shoes and 25.7 % carpets. These items, particularly cloth/shoes, were also found in considerable numbers during the Taff catchment baseline assessment. The high occurrence of both plastics and cloth in the fly-tipping site may reflect the relative importance of such sites as input sources in catchments where these items are found in significant quantities.

Additionally, typical fly-tipped wastes (Coggins et al, 1991) such as household, DIY and transport-related goods, were also found at the site, but in smaller numbers. Whilst numbers of these were small, their generally large size has greater potential to cause offence than other less noticeable waste.

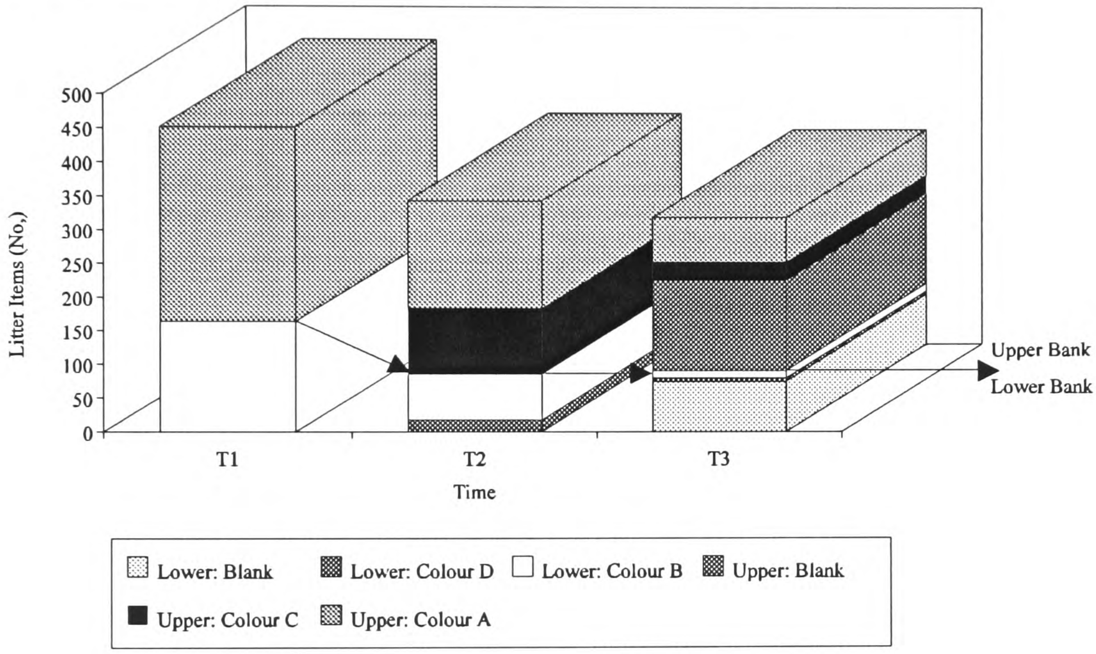
Figure 5.2. Fly-tipping Waste Composition



The sewage-related categories (feminine hygiene, general sewage) should also be mentioned with respect to one particular component, nappies. It was initially considered that these items would be found within the site on the lower bank due to inputs from the river course. However, new inputs of nappies were found on the upper bank at each monitoring period. It must therefore be understood that whilst nappies are sewage-related in their use, their introduction to the river system appears to be via tipping rather than sewage system sources.

Results were then analysed to investigate waste inputs and accumulation on upper and lower banks (Fig 5.3). Initial inputs were high at T1, with predictably greater material amounts on the upper bank near the access point. At T2, new material inputs were recorded but in reduced quantities. These new inputs did not result in an overall increase of waste through accumulation, due to a larger quantity of material leaving the site during this period. At the final monitoring stage, T3, new inputs increased in quantity from T2 amounts, but still did not result in an overall increase in material due to high losses from the site. Results demonstrated conclusively the highly dynamic nature of dumped waste at the site. This is confirmed by a loss of 41 % of the total 778 items dumped by the end of the monitoring period.

Figure 5.3. Input and Accumulation of Fly-tipped Waste



Movement patterns within the site proved rather more difficult to monitor. Tabulated results show item numbers of each colour recorded at each time period, together with losses and new inputs (Table 5.1). Also shown in brackets are the internal movements of marked material within the bank zones. In total, only fourteen marked items were recorded as having moved to different bank sections. Two items from the initial marking (Colour A) moved from upper to lower bank zones at T2, increasing to seven items by T3. In addition, four items sprayed at T2 (Colour C) also moved into the lower bank zone by T3. Surprisingly, a lower bank marked item (Colour B) was also noted to have moved to the upper bank by T3. This may be explained by the removal of a dumped car from the lower bank that may have taken material with it in the process of being dragged up the slope.

Table 5.1. Fly-tipping Material Inputs, Movements, and Losses

Litter Category	No. Items	Time: T1	T2	T3	Total Input	Total Loss
Colour A	**Input**	288	160 (2)	67 (7)	288	---
	Loss	---	128	93	---	221
Colour B	**Input**	164	67	11 (1)	164	---
	Loss	---	97	56	---	153
Colour C	**Input**	---	99	28 (4)	99	---
	Loss	---	---	71	---	71
Colour D	**Input**	---	18	5	18	---
	Loss	---	---	13	---	13
Blank Upper	**Input**	---	---	134	134	---
Blank Lower	**Input**	---	---	75	75	---
Total Resident Items		452	344	320	**778**	**458**
Key: ( ) Marked Items Recorded in New Bank Zone						

Few marked items were recorded as having moved to different bank zones during each monitoring period. When compared with the large numbers of items lost from the site during this time, it becomes obvious that certain activity is going unmonitored. The fate of material lost therefore needs to be considered. It is possible that due to lack of item-specific marking and infrequent monitoring, small items could have passed from the upper to lower bank and into the river flow without being monitored. If this was the case, a far more complicated marking system would need to be employed to follow such activity. Alternative explanations do exist which were formulated from observations during site visits. It was noted that, some time after input, certain smaller less bulky items were becoming incorporated into the bank (Plate 5.1).

Plate 5.1. Burial of Fly-Tipped Material

It is therefore possible that a proportion of the dumped material could become incorporated into the bank if left undisturbed for a period of time, particularly if the bank angle of repose had not been exceeded. Another process observed at the site was reclamation of certain items by children for playing or by adults, if items had a further perceived use. Removal of items was noted to relate mostly to larger materials such as furniture. This scavenging activity was also noted by both LIFT (1985) and MEL (1991, p14) who stated "Fly-tipped waste is usually dumped because it is of little value to the owner and has come to the end of its useful life. In some cases, however, fly-tipped items are not valueless and could be acquired by members of the public seeing it for their own use".

From these results it is difficult to estimate the proportions of items lost to each fate. However, consideration of the general composition of waste lost does indicate which categories accounted for most item losses from the site. Compositional proportions of material losses were fairly consistent throughout this study, hence results have only been tabulated for one example (Table 5.2). An average of approximately 50 % of material lost during each time period was plastic. As plastic offers little reclamation value, and potential for burial would be limited due to the smooth surface preventing soil aggregation, the fate of most of this highly mobile material is likely to be river flow. The next largest groups were textiles and metal objects. During site visits textiles were noted as being the group most susceptible to burial. Some of the textile material such as carpets could also potentially have been scavenged, and some may have passed unrecorded into the river flow between monitoring periods. The fate of this material is therefore not clear but is potentially mixed.

Metal objects were also lost in high numbers during the monitoring period. They consisted mainly of cans which, due to their light weight, were likely to be quite mobile, and therefore had potential for rapid movement into the river channel. Other metal items may have been seen as useful and removed from the site, but few were likely to become buried quickly due to their smooth surfacial characteristics.

Considering results and site observations, it was felt that a high proportion of the less bulky and most numerous items lost from the site, were likely to have moved into the river flow. Bulkier items, present in smaller numbers, were most susceptible to removal through scavenging. These items were unlikely to be buried or show rapid movement into the river flow because of their volume. It was felt that in the short term, only relatively small proportions of waste became buried because very little of it would have suitable physical characteristics. To determine exact proportions of waste entering the river, an in-depth study would be necessary, using item specific tagging and intensive monitoring.

Table 5.2. Composition of Material Lost from Site (Colour A)

Marked Material Type: Colour A					
Material	**T1**	**T2**	**T3**	**% Loss T1-T2**	**% Loss T2-T3**
Feminine Hygiene	0	0	0	0	0
General Sewage	7	3	0	3.1	3.2
DIY Combustible	10	1	0	7.0	1.1
DIY Non-Comb.	6	2	1	3.1	1.1
Brown Goods	2	0	0	1.6	0
White Goods	0	0	0	0	0
Metal	28	14	2	10.9	12.9
Plastic	139	85	33	42.2	55.9
Glass	14	7	6	5.5	1.1
Textiles	54	30	19	18.7	11.8
Motor Vehicles	4	3	1	0.8	2.2
Other Transport	1	0	0	0.8	0
Packaging	6	5	2	0.8	3.2
Miscellaneous	17	10	3	5.5	7.5

Photo-Logs

In the months following the fly-tipping site clearance (May 7th 1992), few new inputs were recorded using photo-logs. Initially tipping was slow, and consisted mainly of small items. Also from May to August it was impossible to record new inputs due to extensive camouflaging vegetation growth (Plate 5.2). The first input of items, large enough to be noted by photo-logs was recorded on September 22nd 1992, when a wheel barrow, car door, some hardboard, and a bin bag of domestic waste were dumped at the site (Plate 5.3). By October 30th 1992, the car door and wheelbarrow had moved, probably during the scavenging process, but nothing had been removed and no new inputs noted. On November 20th 1992, a car was found dumped in the site together with a shopping trolley. The car was resting on the lower bank covering most of the litter in that zone (Plate 5.4). Four days later, the shopping trolley had disappeared together with several car parts. The next major change at the site followed a heavy period of flooding in early December. This caused the car to move further into the river and rotate 90 degrees to face the river flow. On December 9th 1992, more tipping occurred in the form of several large pieces of hardboard and carpet (Plate 5.5). This was added to in January (18th 1993) with the introduction of a kitchen sink, but by February 15th 1993, all these latest items had disappeared. On February 26th 1993, the car also disappeared from the site, even though flows had not been high enough to cause movement. Local enquiries provided an explanation; the car had been removed by a local scrap merchant. Little further tipping occurred in subsequent weeks, with the exception of a dumped mattress recorded on April 13th 1993 (Plate 5.6).

Plate 5.2. Fly-tipping Site: July 1992

Plate 5.3. Fly-tipping Site: September 22nd 1992

Plate 5.4. Fly-tipping Site: November 20th 1992

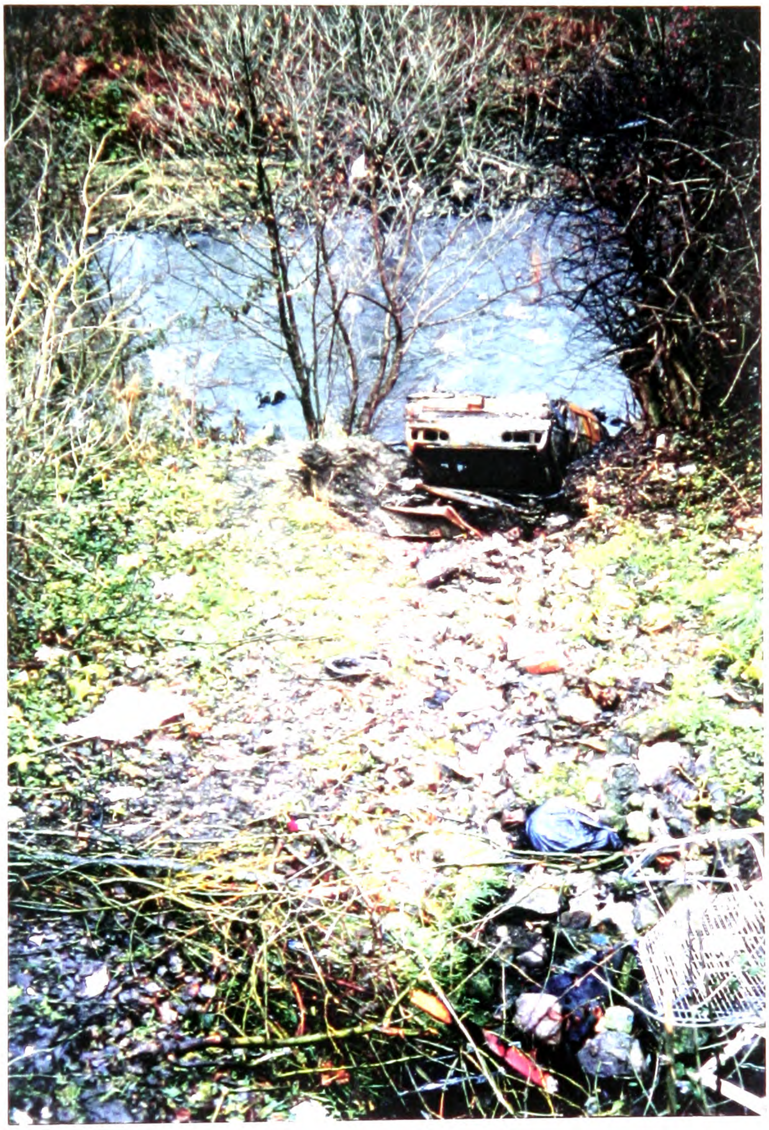


Plate 5.5. Fly-tipping Site: December 9th 1992

Plate 5.6. Fly-tipping Site: April 13th 1993

The photo-logs together with site observations seemed to indicate that larger items were regularly dumped at the site, but that their retention time was limited. Accumulation of these items did not occur, mainly due to scavenging by children or local residents. It is plausible that this activity would not be as common in other sites with a different location or different physical characteristics. Photo-logs provided a useful overview of the site, but interpretation of the results were limited as only larger items could be monitored in this manner.

In conclusion, the fly-tipping site at Penywaun was considered to be quite active. Both inputs and outputs were numerous and its contribution to riverine litter was thought to be great. Attempts at managing the problem through clearance and preventative barricades proved futile (Plate 5.7). The pledging was removed within two months, and tipping increased from this point on. The Penywaun site is a well known fly-tipping site within the Taff catchment, and results provide an initial view of riverine fly-tipping site dynamics. Further studies would be needed to determine how typical the results were. It is clear, due to the widespread nature of fly-tipping within the Taff catchment, that immediate action is needed to tackle the problem.

Plate 5.7. Barricade Destruction at the Penywaun Fly-tipping Site

CHAPTER 6

SEWAGE INPUTS

Introduction

In the early 19^{th} century, sewers were the streams of urban areas. They became progressively culverted during accelerated development, eventually forming a water-borne waste system that became widely accepted. Foul sewers were designed to link into surface water drainage channels, inevitably resulting in discharges to watercourses. In an attempt to control increasing pollution, legislation was passed in the latter half of the 19^{th} century to prevent discharges of untreated sewage to inland watercourses. Early treatment methods included percolation of sewage through soils, and disposal utilising a stream's natural purification system based on large dilution factors. The most common option was treatment on land, where effluent was screened and settled to minimise suspended solids, prior to being added to the land to bring about oxidation of waste materials. However, major drawbacks existed due to the large areas of land required for treatment, unpleasant smells, and the tendency for land to turn septic. This form of treatment has now been superseded by modern techniques using activated sludge or biological treatment.

Modern Sewage Treatment Processes

Modern forms of sewage treatment may be carried out to several levels. Sewage entering a treatment works contains both gross solids in suspension and inorganic material, i.e. grit from roads. Primary treatment involves the removal of these elements, usually through a process of screening and settlement. Aerobic biological treatment can then be applied using naturally occurring organisms to feed on the dissolved material. Settled sewage may then be treated using percolating filters, where circular or rectangular beds, containing a coarse medium such as slag or stone, are dosed with effluent. As the sewage percolates, organisms break down the pollutants, provided an adequate oxygen supply is available, and the increasingly purified sewage is collected at the filter bed's base. Large amounts of suspended material still remain, however, and need to be removed by secondary treatment.

Alternatively, activated sludge plants may be used, and are often preferred as they take up less land than percolating filters. Settled sewage is passed through a series of continuously aerated tanks, where again oxygen promotes bacteriological growth to bring about sewage breakdown. In this case oxygen needs to be actively injected either by pumps at the bottom of the tank or by surface agitation.

Secondary treatment then takes place in settlement tanks similar to those used in primary treatment in order to remove remaining solids from the effluent. Further purification may be carried out by tertiary treatment, which encompasses all treatments beyond the secondary level, but is not standard practice at all works. Methods include more advanced filtering techniques to improve effluents both physically and biologically. The final effluent is then discharged to river, sea or estuary, its impact having been minimised.

An increasing problem for sewage treatment works has been the rise in feminine hygiene products, commonly disposed of through sewers. Physical properties of these items often preclude effective screening even when the most advanced techniques are used (Welsh Water & WRc, 1989). It is the introduction of such items and other sewage-derived litter that is of interest in this section of the research.

Storm Water Overflows

Davies (1989) noted that treatment works are not the main point source of sewage-derived litter, many gross inputs occurring from Storm Water Overflow (SWO) discharges. The majority of sewage systems in the UK were constructed to transport sewage and storm water (combined) to sewage treatment works. During periods of heavy rainfall, increased loads to combined sewers present considerable flood risks. To alleviate this, pressure SWOs were constructed "... for the purpose of relieving the system of flows in excess of a selected rate, the excess flow being discharged to a convenient watercourse" (Jeger, 1970, p65). The selected rate was based on a multiple of Dry Weather Flow (DWF). This posed a problem as no allowance was made to cater for potential rises in future flows or receiving water characteristics and their sensitivity to effluent discharges.

Treatment works are generally designed to give full treatment to flows up to 3 DWF, and provide storage for flows between 3 and 6 DWF, allowing treatment after the flood event. Only when flows exceed 6 DWF should SWOs operate. A final modification was made to this approach by the Technical Committee on Storm Overflows and Disposal of Storm Sewage (1970) to take into account proportions of industrial and domestic elements. This has found wide acceptance within the water industry and is summarised below.

$$Q = DWF + 1360P + 2E$$

Where: DWF = Dry Weather Flow

Q = Overflow setting (litres/day)

P = Population

E = Volume of industrial effluent discharge in 24 hours (litres)

The principal of SWOs is that they only discharge during storm events and that inherent high flows ensure adequate dilution rendering the effluent harmless. This, however, is not always the case. SWOs often discharge outside of storm events, and their impact is not always harmless due to a disregard in design towards receiving water sensitivity.

The majority of SWOs are unscreened, discharging foul untreated sewage to waterways in a supposedly diluted state. This dilution, however, does not alter the impact of sewage litter. To minimise the input of gross solids, new designs have been introduced which emphasise the retention of damaging "first flush" pollutants. It is recognised that the initial discharge of effluent from an overflow is far more polluting than subsequent flows. This is due to the flushing out of solids that have settled out at the end of previous storm events. New SWOs often incorporate storage facilities, allowing such pollutants to be held and transferred for treatment later. Other approaches involve the removal of floaters and sinkers, material with specific gravity less or more than water, by slowing the flow long enough to allow settlement and removal. Neutrally buoyant material such as many feminine hygiene products are much more difficult to remove. Various screens have been tried to combat this problem, but difficulty exists in determining the most effective screen mesh size and cleaning procedure. Screens of greater than 15 mm mesh size are generally ineffective at gross solids removal (Welsh Water & WRc, 1989), but substitution with smaller aperture screens is not always the solution due to the risk of blinding. To prevent blinding, screens may be cleaned either mechanically or manually. Mechanically raked screens require power and regular maintenance, and even then are not totally efficient. Manual alternatives are more labour intensive, but no more effective. Even if these problems could be remedied, screening of all overflows is improbable due to the high numbers and cost involved. New design technology has culminated in dynamic separation overflows, based on the principle that at low velocities the centre of a spinning column of liquid rotates slower than the remaining liquid. In this way, if flows are controlled, settleable solids can be pulled down to the base of the overflow allowing transportation of solids to treatment works, whilst the remaining flow is discharged to suitable receiving waters. The performance of such overflows is at present undergoing much scrutiny to test the claimed screening efficiency.

Wrong Connections

In the few areas where separate sewer systems are in operation, an additional problem has arisen, where foul drainage has been connected to surface water sewers. This is surprisingly common and results in foul sewage being discharged to receiving waters unmonitored. Certain water companies have encouraged residents to have their connections checked and even issue inspection certificates in an attempt to eradicate the problem (Water Bulletin, 1992).

Aesthetic Pollution

"In general the public regard sewers as the natural disposal point for virtually any wastes - both liquid and solid" (Huntingdon, 1990, p1). But as a whole, people do not expect to see items disposed of in this manner again, and find it unacceptable when deposition occurs on riverbanks and beach faces. Sewage-derived litter encompasses all litter that is disposed of via the sewer system, for example, feminine hygiene products (sanitary towels, panty liners, tampons) contraceptives, rags, faeces and cotton buds. However, litter origins are not always so easily determined. Items such as nappies are known to be common on fly-tipping sites (Chapter 5), and typical domestic wastes are sometimes found in sewer systems. The specific sewage litter components that cause offence are as yet undetermined, and is a research area currently being tackled by the NRA (Welsh Region) in collaboration with the WRc.

Method

The study was devised to sample effluent from a range of outfalls to determine litter composition of discharges together with an assessment of the outfall's impact (aesthetically) on the river.

Before selecting SWOs to monitor, time consuming cross-referencing was carried out to link NRA records with those of Local Authorities. Discrepancies existed between the two information sources which often could only be remedied through discussions with personnel in the maintenance department. Due to the time taken to gain up-to-date information, only SWOs on the River Cynon were considered for this study.

In a move to up-date current SWO records the NRA has instigated a large-scale survey of all SWOs in the Taff catchment. Many details were recorded for each outfall, including impacts regarding sewage litter. Analyses were carried out only once, and classifications were based on amounts of sewage litter in the vicinity of each SWO at that time. Therefore the sites chosen for this study were selected to reflect a range of NRA classifications, from gross sewage litter to none observed. In this way, not only could valuable data be collected regarding composition of discharges, but a cross-check was also possible of the NRA classification system (Table 6.1).

Table 6.1. Storm Water Overflow Details

	NRA Consent	NRA Litter Impact	Site Description	Bank	Grid Reference
1	AN0096401	Not Obser.	Penderyn - Arc Quarry	RB	SN9495 0865
2	AN0098901	Gross	Hirwaun - Rear Bute Rd.	LB	SN9555 0575
3	No Record	No Record	Hirwaun - Rear Bethal Pl	RB	SN9610 0550
4	AN0097101	Gross	Hirwaun - S. of A455	RB	SN9610 0540
5	AN0112701	Present	Penywaun - Nr School	RB	SN9800 0495
6	Missing	Present	Robertstown -.Jupitor	RB	SO0010 0355
7	AE2004801	Present	Godreman - Incline Row	LB	SO0125 0020
8	AN0112101	Trace	Aberaman - Nr. Police St.	LB	SO0185 0110
9	AN0109101	Gross	Penrhiwceiber - u/s Stat.	RB	ST0580 9790

Outfalls were assessed by retaining solids from the flow by the attachment of COPASACS. The sacs are specifically designed to retain gross solids from sewer systems, but they are usually used in more controlled conditions, e.g. gross solids samplers. They resemble large onion bags in appearance, and are made of strong plastic material with a 4 to 6 mm mesh, allowing sewer flows to pass through the mesh, whilst solids are retained. COPASACS are produced at a standard 12" (30 cm) diameter and their size was thus limiting as a means of sampling overflows. Selected overflows therefore had to be a certain size to allow attachment and ensure the sac was not by-passed by storm flows.

COPASACS were attached to the outfalls using strong wire, and if necessary, embedded hooks in the SWO housing. Outfalls were monitored on a weekly basis over a twenty week period, and if discharge had occurred, the sac was removed for analysis. COPASAC contents were weighed after excess water had been drained from the sample, after which contents were recorded using specially devised survey forms. Assessments were made using three approaches: presence and absence, log score, and percentage volume (Table 6.2) so that the merits of each could be determined.

Table 6.2. COPASAC Survey Form

River Name			
Nearest Town			
Chamber Grid Reference			
SWO Outfall Grid Reference			
Type of SWO i.e. screening			
SWO Reference No.			
Other Relevant Information			
Date/Time of Installation			
Weight of COPASAC			
Inspection Dates/No Discharge			
Date/Time of Inspection			
Wet Weight of COPASAC			
Wet Weight of Contents			
SEWAGE CATEGORIES	PRESENCE /ABSENCE	LOG SCORE	% VOLUME
Sanitary Towels			
Panty Liners			
Tampons/Applicators			
Contraceptives			
Napkin Liners			
Toilet Paper		N/A	
Faecal Matter		N/A	
Cotton Material		N/A	
Food		N/A	
Cotton Buds			
Plastic Sheeting <30 cm			
Plastic Sheeting 30-60 cm			
Plastic Sheeting >60 cm			
Other: Specify			

Log Scores: 0=0 1-10=1 11-100=2 101-1000=3 >1000=4

Results and Discussion

Initially, nine SWOs were chosen on the basis of NRA ratings, access and suitability of pipe size for COPASAC attachment (Table 6.1). Of these nine sites, assessments of two were abandoned (numbers 4 and 9) due to sampling problems. At site four, a malfunctioning SWO flap prevented proper samples being taken as the flow was directed around the sac. The flow obstruction also caused back-flooding and resulted in sewage emerging from a nearby inspection cover. Gross impact of sewage litter was confirmed at this site (Plate 6.1), but further measurements could not be taken.

Plate 6.1. Malfunctioning SWO at Site Four on the River Cynon

At site nine, it was apparent that no discharge was occurring from the SWO pipe. Further investigations, tracing the pipe back from its river endpoint clarified the reason. The sewage pipe was broken, it's flow discharging directly into a surface water culvert running beneath it. Attachment of a COPASAC to the culvert was not possible so continued monitoring was abandoned. Both sites were seen to contribute gross litter quantities and highlighted the critical role of malfunctioning sewers in causing pollution problems. In both cases, however, a superficial inspection would not necessarily have indicated the malfunctions unless carried out immediately following a flood event (Plate 6.1).

The remaining seven sites were monitored over a twenty week period, in which time four surveys were aborted due to dangerously high flows. During this time, SWO activity was varied (Table 6.3).

Table 6.3. Storm Water Overflow Activity

Site No.	No. of Discharges	General Litter Content	Date (Weight (g))
1	1	Surface Run-off	09/12/92
2	9	Sewage-derived	09/12/92 (2060) 21/12/92 (5) 18/01/93 (105) 29/01/93 (4041) 03/02/93 (5) 11/03/93 (1955) 31/3/93 (2563) 19/4/93 (980) 30/4/93 (705)
3	4	Sewage-derived	9/12/92 (5) 31/3/93 (975) 19/4/93 (523) 30/4/93 (15)
4	Void	N/A	N/A
5	2	Sewage-derived	9/12/92 (16) 29/1/93 (527)
6	2	Surface Run-off	9/12/92 18/1/93
7	0	No Discharge	N/A
8	1	Surface Run-off	9/12/92
9	Void	N/A	N/A

Site 7 did not discharge at all, whilst sites one and eight discharged once, and site six discharged twice. These discharges were considered to be surface run-off because of the conspicuous absence of any sewage litter. Site five also only appeared to have operated twice, but this was thought an under-estimation of its actual activity. The site was located in an area used recreationally by local children, and often COPASACS were removed from the site before samples could be collected. Monitoring of any outfall in a conspicuous area would be likely to suffer the same problems.

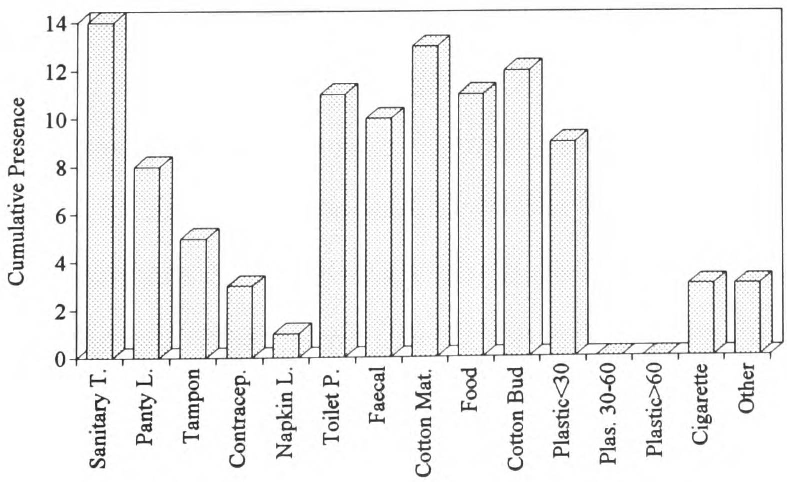
Site three operated on four occasions but was absent from NRA SWO records. The likely reason for this is the close proximity of two outfalls in this area, the downstream outfall being new and more prominent than the one monitored. With present documentation discrepancies it was impossible to determine from records that two separate outfalls exist. Even considering the NRA's current efforts in updating records, there is a strong need for improved interchange of information between Local Authorities and the NRA, particularly regarding any recent work carried out. A further problem in the records was the disparity of grid references locating outfalls. With affordable satellite positioning systems (GPS), accurate locations could be recorded for each SWO, helping to minimise locational errors.

Site four was still monitored to determine if it was operational, and also to bring to light these problems in SWO documentation. The most active site monitored was site two which functioned on nine occasions. Its impact was not so much a result of waste quantities discharged during each operation, but the frequency of discharges. The NRA appropriately categorised this outfall as having a gross litter impact. The other "gross impact" outfalls were due to malfunctions, emphasising the need to locate such outfalls and undertake appropriate repair work. Outfalls categorised as having sewage litter "present" (Table 6.1) were not all shown to contribute sewage litter. No sewage litter was collected in samples from sites seven and eight (Table 6.3). It would seem that litter at these sites was a result of general downstream deposition and not point-source inputs. It appeared that the NRA sewage litter classification was only valid in extreme circumstances, i.e. gross impact or none observed. In other circumstances it was not possible to detect the impact of any one outfall due to the general background levels of sewage litter. In these less clear cases litter classifications would have to be considered in parallel with other pollutant measures, i.e. biological samples.

To determine suitable assessment methods several techniques were used. Simple presence or absence of sewage checklist items could be recorded for each category (Fig. 6.1). A straight count was not possible due to the large quantities of waste collected, so instead log scores were utilised based on Davies' (1989) semi-quantitative approach (Fig. 6.2). Due to their physical nature some items were impossible to count and so were excluded from this assessment, e.g. toilet paper, faecal matter, cotton material and food. Additionally, volume estimates were made as a percentage of total COPASAC contents. For this assessment a "combination" category was used to represent the above named groups (Fig. 6.3).

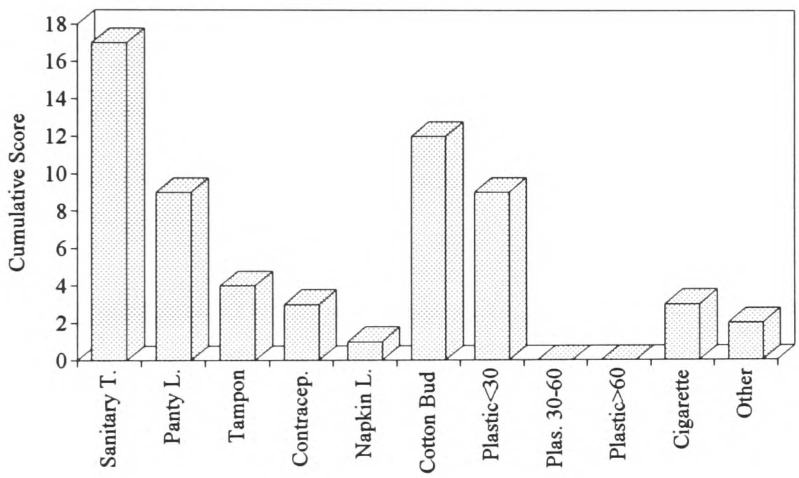
The most suitable assessment is dependent upon result requirements. Presence and absence gave an indication of the most frequently occurring materials during the survey period. The most common sewage litter material was sanitary towels, closely followed by cotton material, cotton buds, food, toilet paper, faecal matter and small pieces of plastic sheeting (<30 cm). All these items were found in over half of the samples collected, and sanitary towels were present in all but two samples. Larger forms of plastic sheeting were absent altogether and only one napkin liner was recorded.

Figure 6.1. Cumulative Presence/Absence of Sewage Litter Categories in all Samples



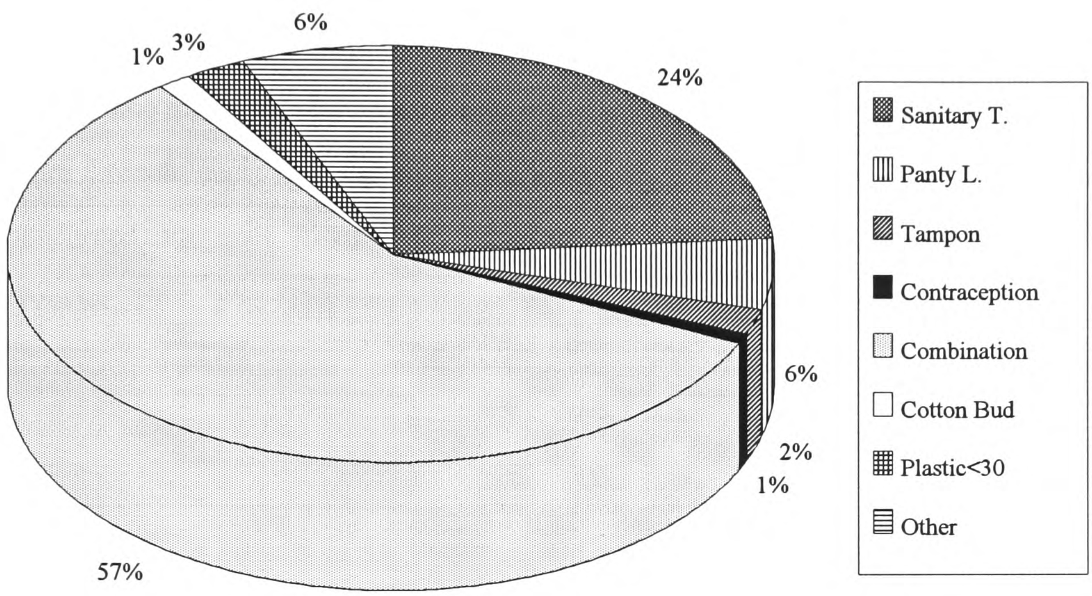
Whilst binary data only represented the occurrence of items, a count gave some idea of actual numbers. Sewage category scores reflected similar compositional characteristics to the presence/absence sewage profile, but results offered little additional information that would only be of use if individual outfalls were monitored with time. In a situation where several outfalls are assessed, the composition is adequately represented by monitoring the presence of litter components. The collection of binary data was also infinitely easier and far less subjective than the semi-quantitative alternative.

Figure 6.2. Sewage Litter Semi-quantitative Assessment for all Samples



Perhaps the most easily interpreted representation was volume (Fig. 6.3). This gave an immediate picture of SWO discharge composition, and allowed some judgement to be made regarding aesthetic impact on an area. Although the highest proportion of waste was a combination of toilet paper, faecal matter, cotton material and food, these materials, from an aesthetic viewpoint, would have limited impact due to their ease of dispersion and breakdown. Contrastingly, the next two largest groups, sanitary towels and panty liners are likely to cause greater aesthetic degradation due to their persistence. Their potential for persistence and visual impact render them a greater concern even though they are not the largest litter component. To gain an informative data set it is recommended that a combination of both presence/absence and volume recordings are carried out, unless specific survey requirements necessitate otherwise.

Figure 6.3. Sewage Litter Composition: Percentage Volume



In all cases, the dominance of sanitary towels as the most numerous SWO discharge component highlights the need to tackle this particular litter pollutant. Technological solutions have been researched thoroughly, and at the present time, even disregarding problems of cost and implementation, no practical fool-proof method is available to remove such products.

As the vast majority of sanitary towels enter water courses via SWOs (Davies, 1989), removal of these inputs would seem to be the solution. Unfortunately, SWOs form an integral part of combined sewer systems, and their presence is likely to be necessary for the foreseeable future. A rationalisation of storm overflows may improve the situation. Certain advances could be made by repairing malfunctioning SWOs and upgrading crude "hole in the wall" outfalls with ones capable of retaining "first flush" pollutants. Even considering these options, inputs could only be minimised, not completely removed. The only means of complete removal is to prevent disposal via the sewer system. The trend in 1992 was for 72% of all towels and 96% of all tampons to be disposed by this route, a dramatic change in customer habits would need to be encouraged (Howarth, pers comm).

Alternatives to the wet disposal route are landfill, recycling, and composting. Landfill is becoming a less popular waste management option, as planning permission becomes more difficult, costs rise, and legislation is tightened. "As far as hygiene products are concerned, the main focus is on recycling and composting of disposable nappies" (Prosser, 1990, p1). This emphasis on nappies is not surprising, as in the USA 2% of all municipal waste comes from disposable nappies. These, however, are not the main cause of concern in this research

"Composting is defined as the breakdown of organic compounds by micro-organisms in the presence of oxygen (aerobic process) at elevated temperature (+ 50 ^{0}C) to produce carbon dioxide, biomass, water and heat" (Prosser, 1990, p2). Procter and Gamble are in the process of examining recycling and composting trials in the USA and Germany, in which household waste is hand-sorted into compostable and recyclable materials. One of the major problems of any alternative disposal route is to set up suitable collection infrastructures. Until recently, some confusion existed regarding the legal definition of hygiene products and hence the appropriate means of disposal. Prosser (1990) considered hygiene products to be clinical waste, i.e. items which consist wholly or partly of human or animal tissue, blood, or other bodily fluids. Under such circumstances they may not be treated as domestic waste, but fall into the special waste category, and therefore may not be put in dustbins. As a result, there is concern over how to advise the public to dispose of these products. "It seems the public cannot be advised directly and told to wrap the product in plastic bags and put them in the normal refuse disposal system" (Westlake, 1990, p1). Westlake (1990) also felt that government legislation would eventually clarify the situation regarding hygiene product waste classification, but that this was not expected in the near future.

With such confusion it was difficult for any decisive action to be taken regarding hygiene product disposal. Pressure groups such as Surfers Against Sewage and the Women's Environmental Network (WEN) have gained high media profiles pushing a "bag it and bin it" campaign. WEN has even started manufacturing disposal bags for sanitary products to encourage consumers to change their habits (The Guardian, 1993).

Now (1993) however, a new draft of the waste management paper regarding clinical waste has helped clarify the situation. The approach is based on determining potential hazards, and suggests that feminine hygiene products can be disposed in normal domestic waste. It is only when increased quantities are concerned that they become defined as "clinical waste" (Howarth, pers comm). On this basis the Association of Sanitary Product Manufacturers (ASPM) now recommends disposal via domestic waste, provided products are securely wrapped. Reflecting this trend, new sanitary products are now available on the market with their own disposal packaging. The promotion of this disposal method has already achieved significant results by reducing sanitary towel disposal via flushing from 72% to 48% (Howarth, per comm). As screenings from sewage treatment works are already disposed of via landfill, a move away from the wet system disposal in many ways streamlines the disposal route for these products. Another supposed "environmentally friendly" option also exists in the form of re-usable sanitary products. These, however, at present have limited popularity and constitute less than 1 % of the current market (Little, 1993).

In summary, assessments confirmed that considerable quantities of sewage litter entered the River Cynon via SWOs, and that there is a need to determine accurate methods for measuring SWO impacts. COPASACS could be used as one approach to assess gross solids input, but their size restrictions need to be addressed. It appears that the immediate way forward is through a combination of rationalising and improving SWOs, together with reviews of alternative disposal options for sanitary products.

CHAPTER 7

MOVEMENT PATTERNS

Introduction

Movement patterns were investigated using a variety of techniques. Emphasis was placed on determining the mobility of litter items so that accumulation patterns and eventual sinks could be better understood. Information on litter mobility was also essential for the formulation of future river litter management policies to help ensure their effectiveness in creating long-term solutions.

1) Time of Travel Study

"The quality of river water depends upon the hydrogeology of its catchment and on the use of its land and water resources" (Inverarity et al, 1988, p3). Litter may not have direct detrimental effects on river water quality, but the implications for the watercourse are not good. As with any other pollutant, to be effectively managed its impact and mobility must be understood. Due to the varied nature of both rivers and potential pollutants, it is impossible to plan for all pollution eventualities, hence models are often devised to allow simulations of pollution incidents. It is possible, if a database contains enough relevant and accurate information, to extrapolate results to give information on a new situation based on key characteristics. In this way the need for reactive measurements during an incident are obviated, allowing critical immediate action to be taken.

A river quality model currently used by the NRA (Welsh Region), and developed by Welsh Water Authority (WWA) in collaboration with Newcastle upon Tyne University

(Morris, 1986; Bird, 1987) is the Time of Travel predictive pollutant dispersion model. Time of Travel (ToT) studies based on tracer techniques, use fluorescent dye (Rhodamine WT) to measure river velocity and diffusion producing output plots of downstream concentration against time. In this way, if the source, input time, approximate pollutant quantity and major discharges and abstractions are known, the likely ToT may be predicted based on flow regimes.

Databases are formed for each river by collecting ToT information at several reaches under varying flow conditions. It was felt that if a constant relationship could be identified between litter and Rhodamine WT movement, then it would be possible to utilise the ToT model to predict litter movement by extrapolation, in the same way as any other pollutant.

Reach Selection

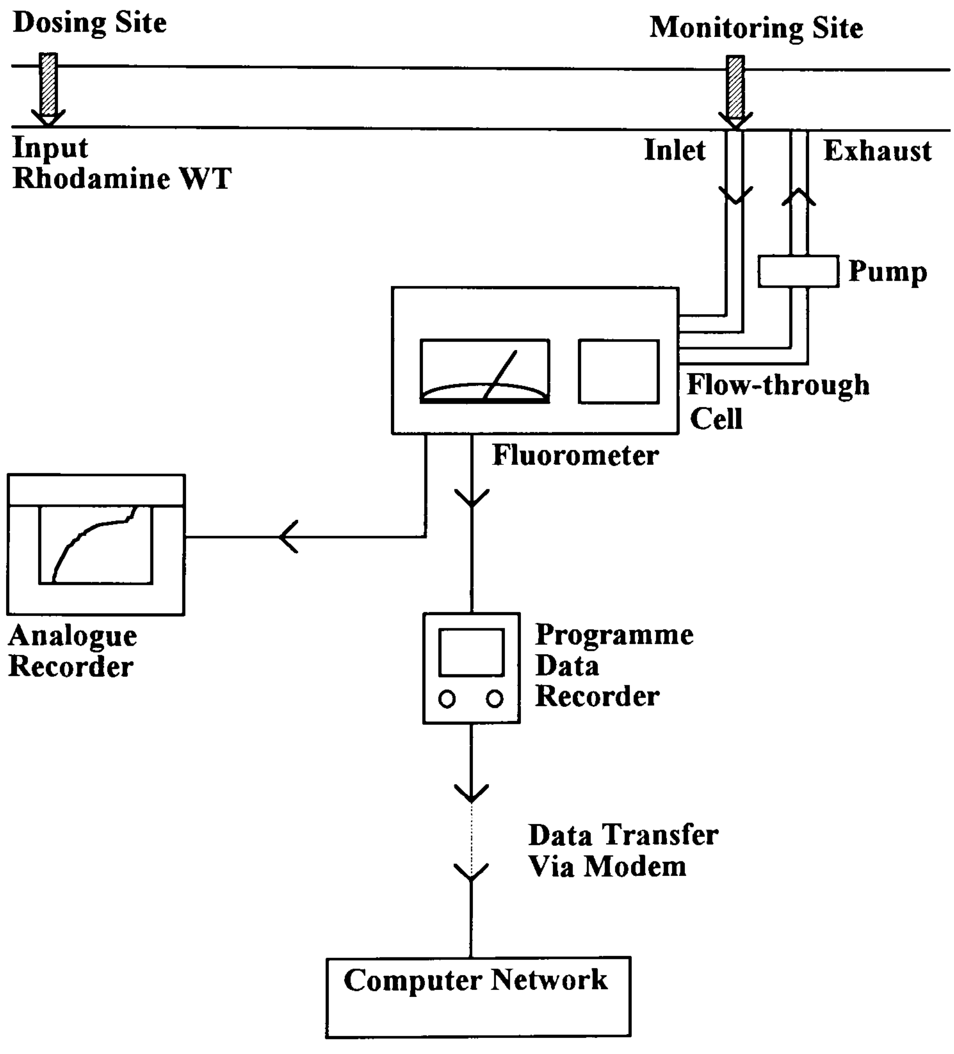
Certain criteria need to be fulfilled by reaches used in ToT monitoring. Flow should not alter markedly within a reach, for example due to confluences, and significant abstractions and discharges should be avoided. Inverarity et al (1988), suggested that such conditions could be met by coinciding reach boundaries with these features. The length of reach must also be considered to allow suitable mixing of the dye, and monitoring within a reasonable time scale. "Reach lengths will not normally be greater than 10 km and not less than 1 km" (Inverarity et al, 1988, p5).

The dosing and monitoring sites must offer suitable access. At dosing sites, dye needs to be evenly distributed across the river's width in the minimum time possible, making bridge sites most eligible. Downstream, the monitoring site should permit installation adjacent to the water's edge and offer nearby vehicular access.

Equipment

Velocity and diffusion are measured by the addition of a predetermined quantity of fluorescent dye (Rhodamine WT) across the river's width, whose fluorescence may then be monitored a measured distance downstream. Figure 7.1 shows a diagrammatic representation of the monitoring equipment.

Figure 7.1. Time of Travel Sampling System



River water is pumped into the fluorometer's flow-through cell, where an electrical signal is generated proportional to the fluorescence measured. The signal is logged on a voltage recorder for subsequent data processing, and a graphical output is produced *in situ,* allowing correct operation to be checked.

Dye Weight Calculation

Inverarity et al (1988) suggested that the dye quantity used should produce a peak concentration of < $2\mu g\ l^{-1}$ at the monitoring site. To achieve the appropriate dye weight, the following formula was given:

$$M = 2Cp.\, A^{3/2} \sqrt{\frac{XD}{Q}}$$

Where: M = Weight of dye (kg)
Cp = Peak concentration (kg m^{-3})
A = Mean cross-sectional area of reach (m^2)
X = Distance (m) between dosing and monitoring sites
D = Longitudinal diffusion coefficient ($m^2\ s^{-1}$)
Q = Flow ($m^3\ s^{-1}$)

Many of these variables may be obtained from gauging stations, maps, and other archived sources. However, if information is unavailable, broad guidelines may be obtained from the USEPA (1985) handbook on surface water modelling.

Flow Measurements

Ideally, flow measurements should be recorded by hydrologists at both dosing and monitoring sites on the day of the survey. When impractical, flow data may be used from the nearest flow gauging station, ensuring appropriate adjustments are made for the site's location.

Dosing

The optimum dosing procedure requires instantaneous and uniform dye release across the river's width. This is often difficult to achieve, but may be attempted using either bucket or pump release methods. Bucket release, as used in this study, is the most common method due to its simplicity.

Bucket Release: A predetermined volume of dye is mixed with 5 litres of water in a bucket, and then poured across the width of the river. This method is very simple, and extremely effective when dosing is carried out from a bridge spanning the river. In the absence of a bridge, however, the range is somewhat limited.

Pump Release: A predetermined volume of dye is mixed with 10 litres of water and pumped into the river through a diffuser extended across the river's width. This method is usually used when bucket release is not an option. It is relatively complex, and often problematical if the diffuser needs to be placed and no bridge is available.

Timing

Immediate monitoring after dosing is unnecessary due to the time delay needed for the dye to reach the monitoring site. Estimates of velocity may be calculated from previous studies if flow data are available and relative adjustments are calculated. Alternatively, approximate river velocity may be calculated by timing the movement of the dye's leading edge over a short distance, and extrapolated for the reach's entire length. This is of course a crude measure, susceptible to error from flow variations within the reach.

Logging Frequency

The logging frequency should ensure enough points are recorded to produce an adequate peak. Inverarity et al (1988) suggest the following formula should be applied:

$$S = Te * 12$$

Where: S = Logging frequency (s)
Te= Estimated travel time (hr)

Setting-up Equipment and Recording

To establish a stable baseline, the equipment should be monitoring for approximately one hour before the estimated fluorescence arrival time, and should continue until the tracer has passed and a baseline has been re-established. River temperature should also be recorded at both the beginning and end of the monitoring period, as fluorescence is temperature dependent and adjustments may need to be made if temperature fluctuations occur.

Pilot Study

Method

From potential sites surveyed, a 1.25 km reach of the Cynon was selected, based on ToT reach selection criteria. The Aberdare reach, between Robertstown Industrial Estate (SO 0040 0295) and a site adjacent to Aberdare sports centre (SO 0100 0207) possessed suitable criteria for the study.

The appropriate dye weight was calculated at 0.04 kg, and mixed with 5 l of water for bucket release at the upstream dosing site. Flow measurements were obtained from Abercynon gauging station, and appropriate corrections were made for Aberdare's upstream location. An approximation of ToT for the front pulse was made, measuring the dye's initial movement over 20 m, and extrapolated to 1.25 km.

Plastic Tracers

Low Density Polyethylene (LDPE) sheeting was selected for use as a litter tracer. The plastic sheeting was considered suitable as it formed the most common constituent of riverine litter, its movement therefore being of interest. Initially, 180 pieces of brightly coloured LDPE squares (20 x 20 cm) in size, were introduced at the dosing site. Specimen size and colour were selected specifically for ease of identification. The plastic tracers were then distributed across the width of the river in unison with the Rhodamine WT dye, and their progress monitored at the same downstream site (Plate 7.1).

Plate 7.1. Input of Rhodamine and Plastic Tracers at Dosing Site

Results and Discussion

The pilot ToT study was undertaken on June 17th 1992, during steady, low flow conditions. Abercynon gauging station supplied the mean daily flow value (0.497 cumecs), which was adjusted to 0.61 cumecs for the Aberdare area. Information such as the mean flow and mass of dye, were inputted to a FORTRAN program, together with information from the data logger (Table 7.1). The program then calculated both the mean velocity (v) and longitudinal diffusion coefficient (d_l).

Table 7.1. Time of Travel Pilot Study Results

Parameter	Quantity
Mass of dye released	0.004 kg
Mass of dye recovered	0.0042 kg
Measured flow (Abercynon)	0.497 cumecs
Calculated flow (Aberdare)	0.61 cumecs
Time of Travel to front pulse	2.3 hours
Time of Travel to peak of pulse	3.5 hours
Speed of travel	0.0929 m s^{-1}
Dispersion coefficient	1.5649 m^2 s^{-1}
Sum of squares error of fit	9.1448
Background concentration	0.01 ppb
Peak concentration	1.2 ppb

A graphical output was produced, of observed and modelled dye concentrations against time (Fig. 7.2). Table 7.1 and Figure 7.2 indicated a close match between mass of dye released and mass recorded. Similarly, the proximity of predicted and measured flows and peak concentrations suggested "that the true, direct Time of Travel under those conditions was measured" (Boswell, 1992, p2). The ToT for this reach was fairly slow, reflecting the low flow conditions at the time of monitoring. This proved problematical for plastic tracer movement due to enhanced probability of stranding.

Initial plastic tracer movement followed the same path and approximate speed as the Rhodamine WT dye. However, during the six hour monitoring period, no plastic tracers were recorded at the downstream site. Low flow conditions resulted in 100%

entanglement of the sheeting on protuberances within the river channel. Further inspection showed that none of the tracers had travelled any greater than 80 m downstream from the dosing site, stranding usually occurring at the first obstruction. It was felt that higher flows were necessary within the reach, if the two methods were to be realistically compared.

Tracer movement continued to be monitored, to provide results for low flow conditions, but using a revised method to account for their slow progress downstream. The reach was split into 20 m length assessment areas, starting from the dosing site i.e. 0-20 m, 20-40 m etc. Due to minimal daily movements, tracer numbers within each section were recorded on a weekly basis (Table 7.2).

Table 7.2. Plastic Tracer Movement from Dosing Site

Distance from Dose Site	**Monitoring Time**				
	Dosing 17/6/92	**Week 1 24/6/92**	**Week 2 1/7/92**	**Week 3 8/7/92**	**Week 4 15/7/92**
0 - 20 m	101	83	38	9	5
20 - 40 m	32	14	36	15	9
40 - 60 m	34	45	50	62	49
60 - 80 m	9	18	27	35	50
80 - 100 m	0	0	5	13	15
> 100 m	0	0	6	11	12
Total No. Recovered	176	160	162	145	140

Figure 7.3 indicated that only small-scale movement of plastics occurred during low flow conditions. Even after one month, few (12) tracers had travelled further than 100 m from the dosing site. However, gradual downstream movement was noted, the bulk of plastic tracers being found progressively further downstream on each assessment. No consistent pattern was seen in the distribution of tracers, probably due to their movement being guided by random contact with obstructions rather than flow. Under such conditions it was therefore concluded that plastic tracer movement was minimal and demonstrated no correlation to dye transport.

Figure 7.2. Pilot Study Time of Travel Results - Rhodamine WT Peak

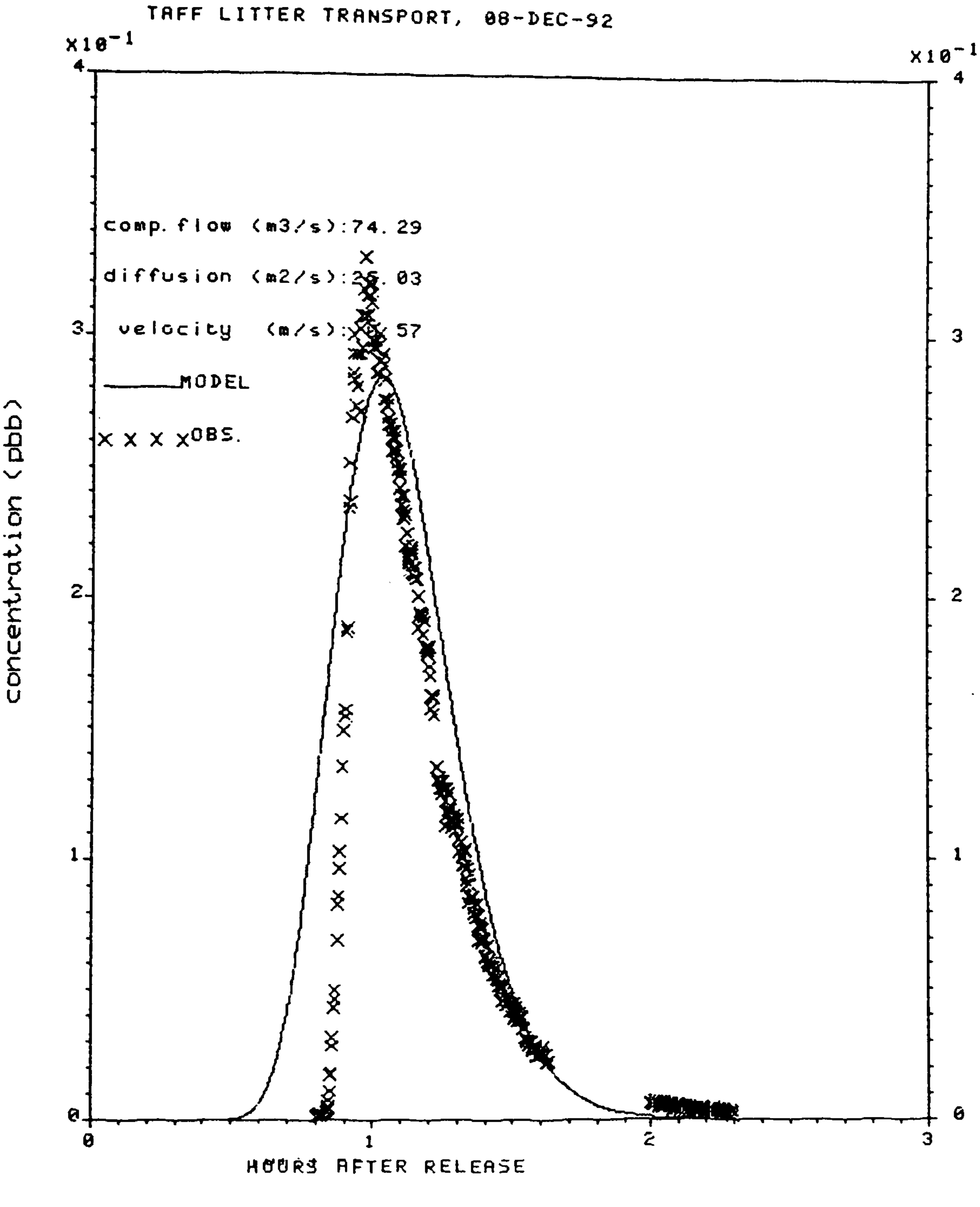
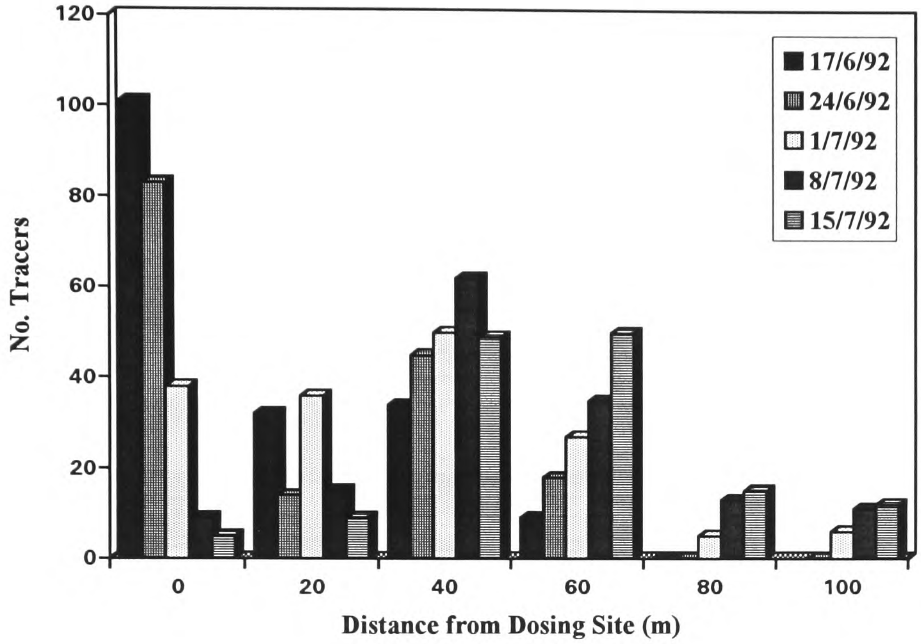


Figure 7.3. Pilot Study: Plastic Tracer Movement Patterns



Study 2

Due to the time consuming, costly nature of ToT experiments, and the problems caused by the reach's slow flow, an alternative faster flowing reach was chosen for the second study, minimising the likelihood of excessive stranding. The reach was a 2.175 km length of the River Taff, stretching from the dosing site at Ynys Bridge (ST 1266 8257), to the monitoring site at the east end of Radyr Weir (ST 1309 8079). A period of high flow was chosen for the study to contrast with the earlier attempt. Monitoring took place on December 8th 1992, the first dry day after a prolonged period of exceptional rainfall. Mean daily flow was provided by Pontypridd gauging station (32.9 cumecs) and was calculated at 74.29 cumecs for the Radyr site.

Method

The method for ToT study was followed as outlined previously with the exception of the dosing technique. Ynys Bridge, used for release, necessitated the Rhodamine dye input to be via three discrete plugs, approximately quarter, half and three-quarters of the river width. Identical plastic tracers were used for this second study.

Results and Discussion

Time of Travel results were processed as before. The mass of dye recovered again indicated that a true direct Time of Travel had been recorded. High flows resulted in a decreased monitoring period of only three hours, and a reduction in tracer stranding incidents. Eighty of the 180 sheets were recorded during this time, the first tracer arriving five minutes before the Rhodamine. Time of Travel results usually form a Gaussian shaped curve when fluorescence is plotted with time. During such high flows the graphical output becomes leptokurtic due to less longitudinal dispersion, and the initial fluorescence recordings increase quickly resulting in a skewed distribution (Fig 7.4). Plastic tracer movement under high flow conditions also appeared to emulate this pattern. The first tracer's arrival was followed by a deluge within the following fifteen minutes. Highest numbers were recorded within the first two, five-minute monitoring periods, proceeded by a sharp decline in numbers, with only one or two tracers recorded in each interval after the first forty minutes. These results also produced a very skewed distribution when plotted (Fig. 7.5).

Figure 7.4. Study 2: Time of Travel Results - Rhodamine WT Peak

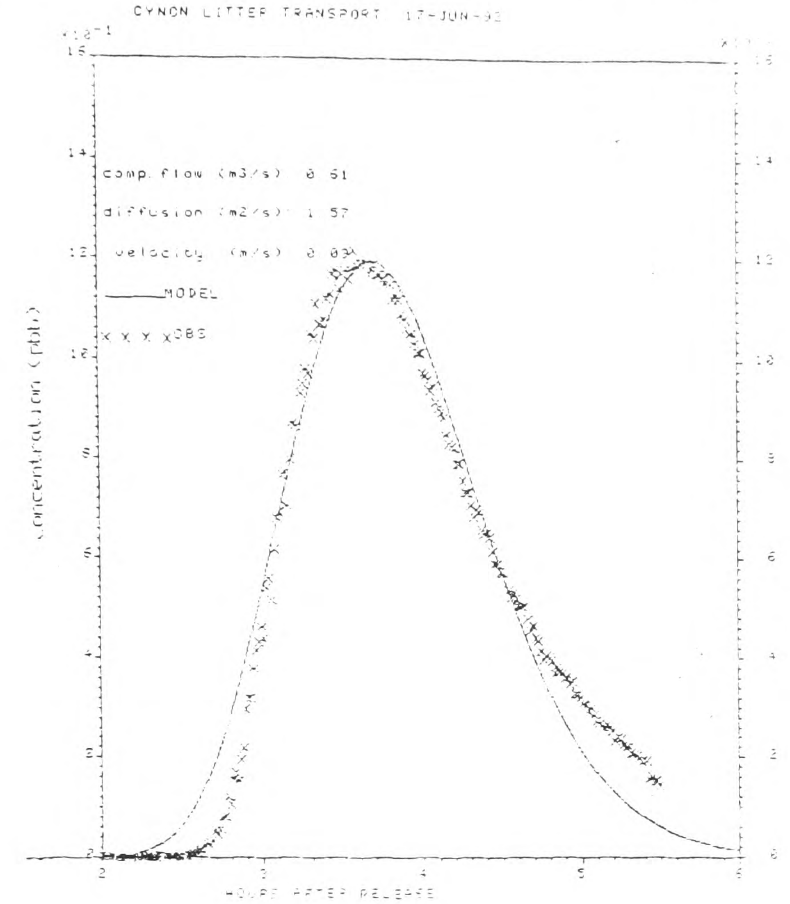
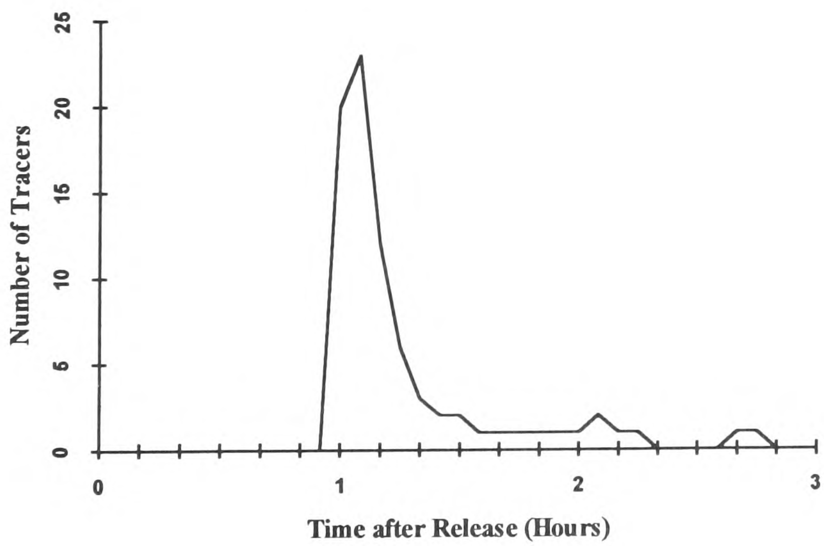


Figure 7.5. Study 2: Plastic Tracer Movement Patterns



Results indicated that ToT and tracer movements showed more similarity during high flow conditions, but that still a surprisingly large number (56%) of tracers were stranded. After the three hour monitoring period, the entire reach was surveyed for the remaining tracers. They were found strewn along the entire length of the reach, wherever protuberances had filtered them from the main flow, or where eddies prevented further progress. Subsequent monitoring showed haphazard release of the tracers from these situations whenever the immediate surroundings altered in some way, for example, due to flow fluctuations or random collision with other items transported in the watercourse. The high proportion of stranding, even during very fast flows, demonstrates the effectiveness of riverbanks in filtering litter.

Study 3

Further studies were carried out simply dosing the river with plastics, without parallel ToT surveys. Litter movement appeared to be only loosely linked with ToT results, the flow conditions being just one parameter out of many which controlled progress. It was therefore decided that due to already existing ToT data on the Radyr reach, continued parallel dosing would be an inappropriate use of resources. Instead, the results were linked with basic flow data, and assessments were limited to one reach.

Additional methodological adaptations were made to look at movements of two differing material types under the same flow conditions. In addition to the 180 plastic tracers, 180 panty liners were also released at the upstream site. With this exception, the method was followed as before.

Results and Discussion

Dosing took place on March 9th 1993, during low steady flow conditions (5.38 cumecs). The first tracers were recorded after 2 hours and 52 minutes and 3 hours and 23 minutes respectively for the plastic tracers and sanitary towels. This was, however, followed by an extensive period of inactivity, with only nine further tracers (plastic) passing during the next 7 hours. The assessment was abandoned after this time due to poor visibility. It was concluded that even at Radyr Weir, where the river is considerably broader and deeper than at the Cynon reach, movement is very limited during light flows.

Study 4

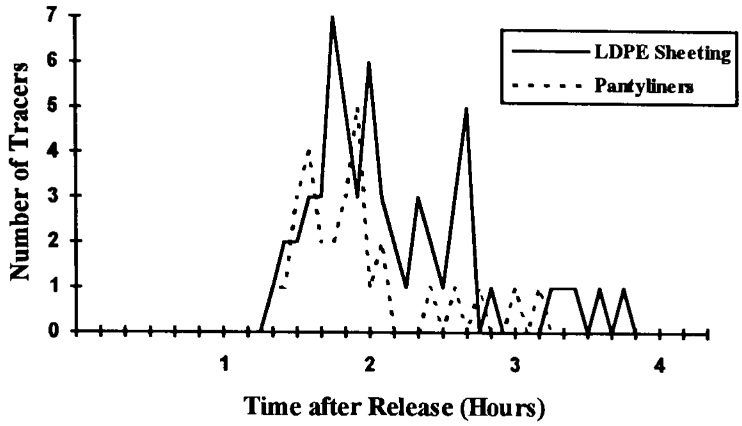
The two sample dosing technique was attempted again at Radyr Weir on April 22nd 1993, when flow conditions were considered high enough (17.72 cumecs) to produce reasonable tracer movement. Methods were followed as before, in a replication of study three.

Results and Discussion

Flow conditions were moderate and steady during the monitoring period (17.72 cumecs), providing improved recapture numbers. A total of 59 plastic tracers and 30 panty liners were recorded during the 4 hour assessment. Unlike study 2, during high flow conditions, initial numbers were low, with no initial surge of tracers. Instead, the distribution was much broader, with the highest numbers of both tracer types occurring during the first hour, followed by a gradual decrease (Fig. 7.6).

Recapture numbers for both tracer types were low, even during moderate flow conditions. Panty liner strandings were surprisingly more numerous than for the larger plastic tracers, but recorded a similar profile. Subsequent observations suggested that panty liners were more susceptible to retention by bankside eddies, and could easily be drawn out of the main current.

Figure 7.6. Study 4: Plastic Tracer Movement Patterns



Overall Discussion and Conclusions

The four movement studies provided valuable insight into aspects of litter transportation. Fast-flowing water proved necessary for any significant litter movement, but even then proportion of items recaptured was low. For the majority of tracers, stranding came rapidly. It appeared that higher flows reduced stranding occurrence but that, under such conditions, longitudinal dispersion of litter following input was limited. Even during exceptionally high flows (74.29 cumecs, December 8th 1992), only 44% of tracers progressed beyond the 2.175 km monitoring reach. The smaller panty liners proved more susceptible than LDPE sheeting to stranding, indicating the possibility of enhanced mobility with increasing size.

Results showed that litter movements were predominantly controlled by reach characteristics such as vegetation overhang and watercourse obstructions. These features seemed to consistently remove high proportions of the tracer's input, regardless of flow. It is therefore likely that any litter with physical characteristics similar to those of the tracers would move only short distances at a time, and become stranded very easily, even in high flows. Subsequent movement occurs only when the immediate external conditions alter in some way. It is therefore probable that a high proportion of plastic sheeting stranded on river banks remains resident until the next rise in water level. Any movement which does occur is likely to be dependent on river flows, making overall downstream progress variable. The comparatively higher number of panty liners stranded meant that transportation following any bulk input, for example, storm water effluent, would usually be limited to short distances. Stranding would most likely occur in the immediate vicinity of an input point unless clear of obstructions, and further transportation would be limited to a succession of short advancements.

Observations were limited in their number, location and the tracer types used. Nevertheless, valuable information was gained, providing an initial view of factors influencing transportation of these litter types. Comparisons with ToT results were limited as litter movement was controlled by a greater number of factors than the dye tracer. Clearly there may be potential for following the ToT model, adapting it to produce a litter movement model if the relevant transportation parameters could be identified and their relative effects quantified.

2) Clearance Study

Introduction

Litter movement patterns were also monitored using a specially devised survey method based on the prior clearance of a 100 metre stretch of riverbank on the River Cynon. Although litter removal produces a somewhat doctored site, it enables studies to be carried out from a known starting point, and provided essential information to assist baseline survey interpretations. By clearing a large area, it was possible to record input rates, accumulation times, and by using marking techniques, movement patterns of litter. The study was devised to give an overview of the processes involved in litter movement and to test the suitability of certain monitoring techniques.

Considerable manpower was needed to achieve complete removal of all litter within the survey area. Lengthy negotiations took place with several organisations regarding the provision of manpower (probation services, educational establishments, Local Authorities), many declining assistance on the grounds of perceived health risks. Eventually, however, Employment Action offered the services of its members to undertake the work. Based in Aberdare near the River Cynon, Employment Action requested that the clearance site be situated in the vicinity, and in an area where improvements could be appreciated by the public. This request did not compromise study aims, and so after consultation with the Local Authority a site was chosen below Aberdare town centre adjacent to the swimming pool. The site consisted of a natural bank with moderate vegetation cover that would have been classified 'C' in baseline assessment ratings. Fly-tipping was not noted to be a problem on this stretch of river, but a sewage pipe was present in the locality. Due to the proximity of a footpath running parallel with the river, diffuse litter was common, particularly drinks and confectionery wrappings likely to have originated from swimming pool dispensers.

A team of approximately five men worked for one week (30^{th} October 1992) to remove all bankside litter, and carry out improvements to the area immediately surrounding the footpath (Plate 7.2).

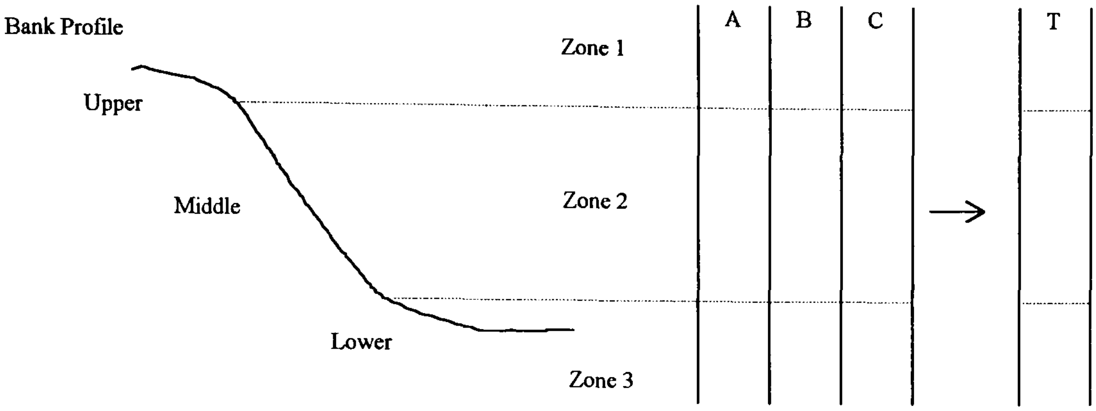
In total, eight 100 litre capacity refuse bags were filled from the 100 metre stretch, weighing a total of 43.3 kg. Clearance and improvement works extended beyond the study area limits, but within the study area extra care was taken to remove even the smallest litter items. Having achieved a litter free site, surveying areas were immediately marked out allowing surveillance to begin without delay.

Plate 7.2. Employment Action Team Working at the Clearance Site

Method

The 100 metre bank length was subdivided into 20 five-metre wide consecutive transects, that for the purposes of this study were named "cells" and labelled A to T. Permanent paint was used to make inconspicuous marks on the upper and lower banks at five metre intervals. A tape could then be extended to join these marks during surveillance, forming boundary markers. Five metre widths were chosen to retain consistency with other studies in this research, and to allow horizontal litter movement within the site to be observed. The study area was then subdivided vertically into upper (1) middle (2) and lower (3) bank "zones" to provide as assessment of movement patterns in this plane (Fig. 7.7). These subdivisions could be easily determined from natural breaks in the bank slope.

Figure 7.7. Clearance Study Site Plan



The standard checklist (Appendix A7) was used to assess litter within each upper, middle and lower bank zone of all 20 cells. Monitoring was carried out initially every few days increasing to fortnightly intervals, for a four month period (until February 1993) to allow significant litter accumulation. Marking of items could not be delayed beyond this point as interference from vegetation would preclude assessments beyond May.

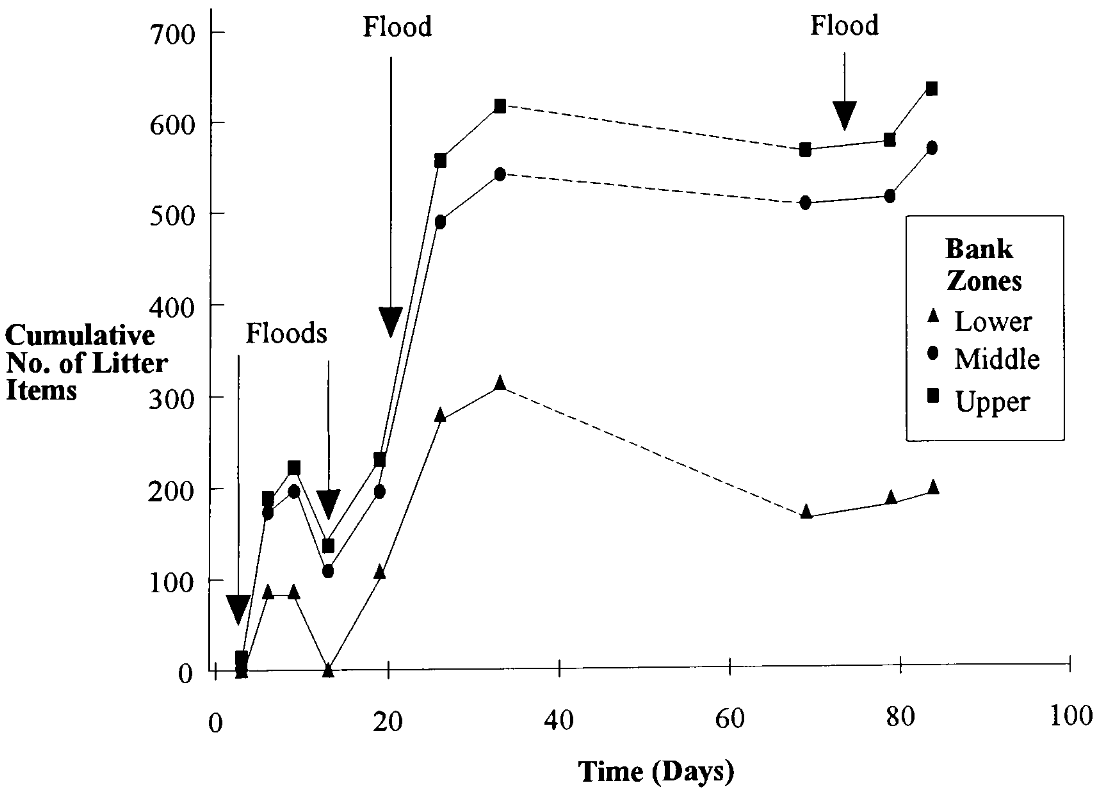
Four consecutive cells (H, I, J, K) were chosen for marking; their high litter content and central position allowing the best possible chance for recording potential movement. Within these cells, upper zone items were sprayed yellow, middle zone orange, and lower zone blue. Without item or cell specific marking, movement within zones between cells could not be recognised. However, movement between zones and beyond outer cell boundaries could be recorded using this method. Assessments from this time (March 4th 1993) concentrated on the marked cells, and downstream monitoring of marked items. Upstream areas were always checked in case of wind-assisted movement in this direction.

Results and Discussion

Four periods of flooding were experienced during the monitoring period (2/11/92 - 23.69 cumecs, 09/11/92 - 14.20 cumecs, 2/12/92 - 74.95 cumecs, 29.18 cumecs). In all cases the lower bank became submerged, and during the third flood, the water level rose to cover most of the middle bank. The accumulation of litter items after clearance appeared to be greatly affected by these flood events (Fig. 7.8). Following each flood, a dramatic increase occurred in overall litter numbers. The magnitude of increase also appeared to roughly reflect the degree of flooding, demonstrated by the largest increase occurring after the third flood period when highest flows were experienced (74.95 cumecs).

Litter accumulated rapidly following flooding, and continued to do so for some time after the water level receded. Increases in deposited litter gradually levelled off with time, until the next flood caused another high input. The drop in litter numbers recorded on day 13 (Fig. 7.8) was due to much of the site being submerged during that assessment. A break in monitoring unfortunately occurred during the middle of the assessment period, as indicated by the dashed line.

Figure 7.8. Accumulation of Litter in Bank Zones

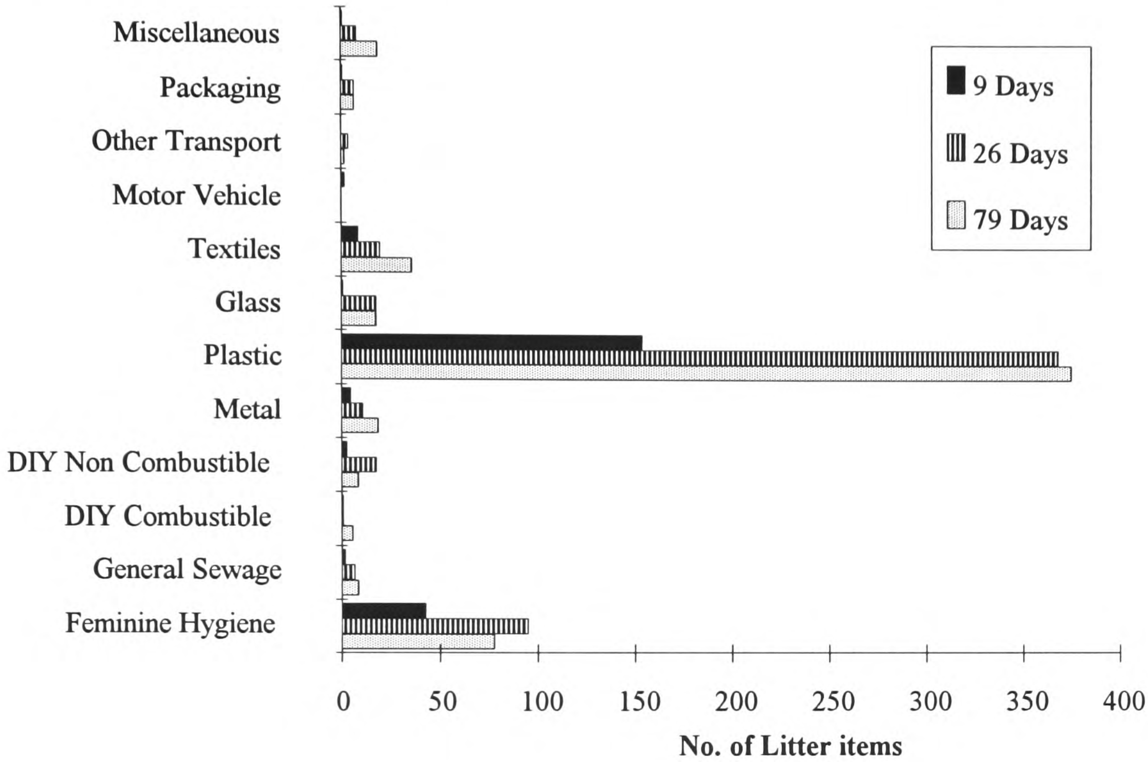


Litter quantities varied greatly between the three zones. Contributions to the upper bank, which could be considered to reflect diffuse inputs, showed a very slow increase in litter with time. Lower and middle bank zones accumulated much higher litter quantities; the greatest number being recorded in the middle bank zone. Results suggested that, at this site, inputs from diffuse sources were minimal and slow to accumulate in comparison with river flow contributions. Greater litter quantities found in the middle bank zone probably reflected the lower level of interaction this area had with the river flow. The lower bank may be scoured, or may receive new inputs during small flow fluctuations. As such its components are likely to be more mobile. Middle bank litter is likely to be deposited only during very high flood conditions. As such these items are likely to have a longer residency times. These theories were considered in greater depth in the analysis of the marked cell results.

Entire site litter compositions were summarised for three different survey periods (Fig. 7.9). Plastic and feminine hygiene groups formed characteristically dominant parts of the litter profile. These items increased in number consistently throughout the monitoring periods shown, with the exception of feminine hygiene items at the last monitoring period. An explanation for this may be that the survey carried out on day 26, followed the greatest period of flooding which was likely to introduce large amounts of sewage-derived material via SWOs. With lesser flooding events, lower input numbers would be expected, but losses would still be likely from sites.

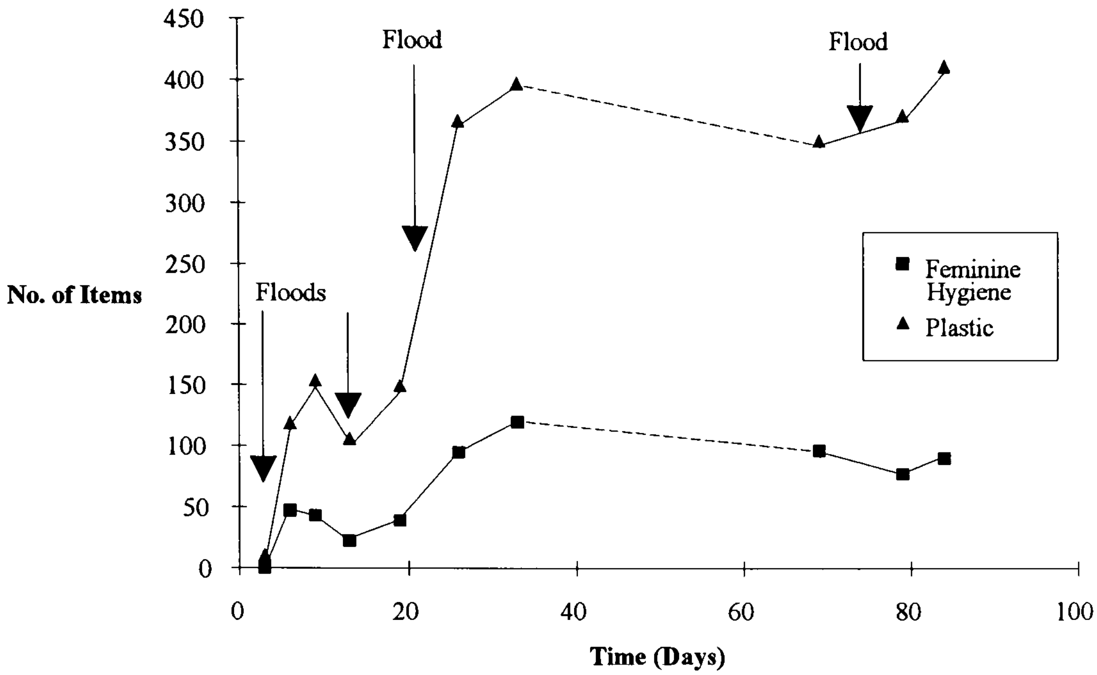
Other groups formed only small proportions of the total waste, most showing slight increases with time. However, numbers were not deemed high enough to warrant further discussion.

Figure 7.9. Litter Composition at Three Survey Times (7/11/92: 24/11/92: 29/1/93)



A closer examination was made of the two main litter components (Fig. 7.10). Both plots followed a similar pattern in response to flooding incidents, but plastics showed greater accentuation of this trend due to the higher numbers recorded. Although accumulation patterns were similar for both groups, the processes responsible for each are likely to be quite different. Feminine hygiene items may be considered as having an input directly related to flood events via SWOs. In this case total numbers within the catchment could be expected to rise during a flood event. Plastics, however, do not increase in number as a direct response to high water levels, total numbers within the catchment being likely to remain the same. Why, therefore are increases in plastics recorded in response to flooding incidents? An explanation could be the redistribution of plastics during high flows.

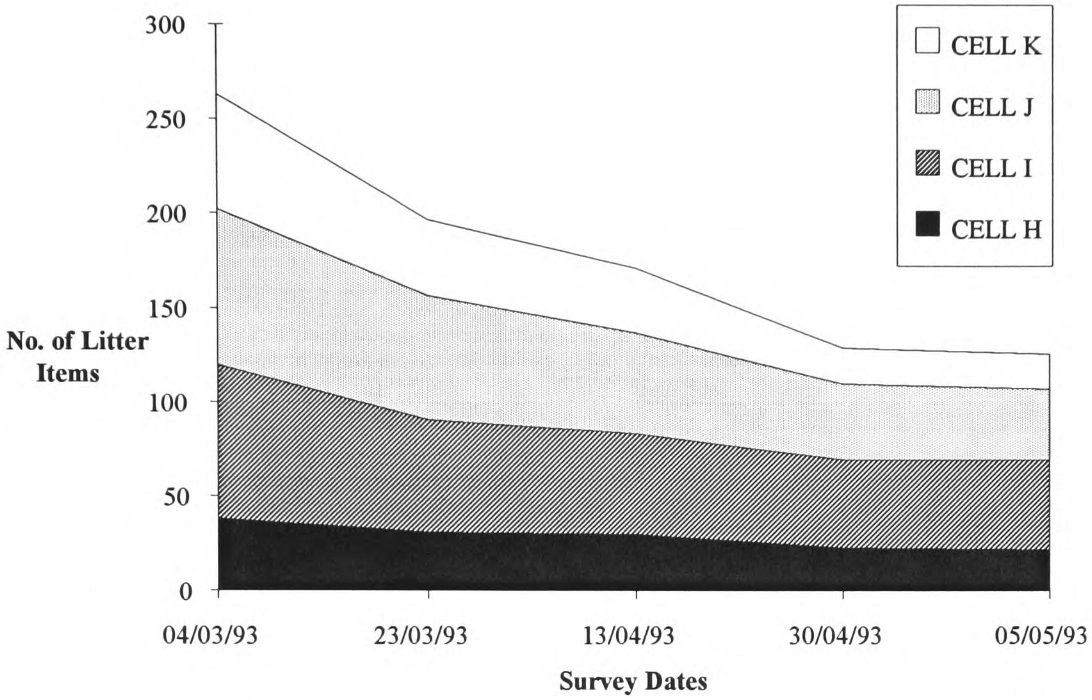
Figure 7.10. Accumulation of Most Numerous Litter Groups



Open sites with little vegetation to retain items such as plastics, could potentially become cleansed during a flood event, whilst areas with characteristics that lend themselves to retention of material, for example through stranding, could undergo large-scale deposition. This research has shown fly-tipping to be a significant point-source input for plastics (Chapter 5). Losses may therefore occur at these sites during flooding. The possibility of redistribution of litter during flood events would be an interesting area for future research.

Litter spraying in selected cells (H, I, J, K) within the site provided some interesting results regarding litter movement patterns. Figure 7.11 shows the overall loss of marked material from the site with time. Results tended to indicate any movement that occurred was for long distances. In that way items disappeared from the site without trace of any intermediate movement within the site.

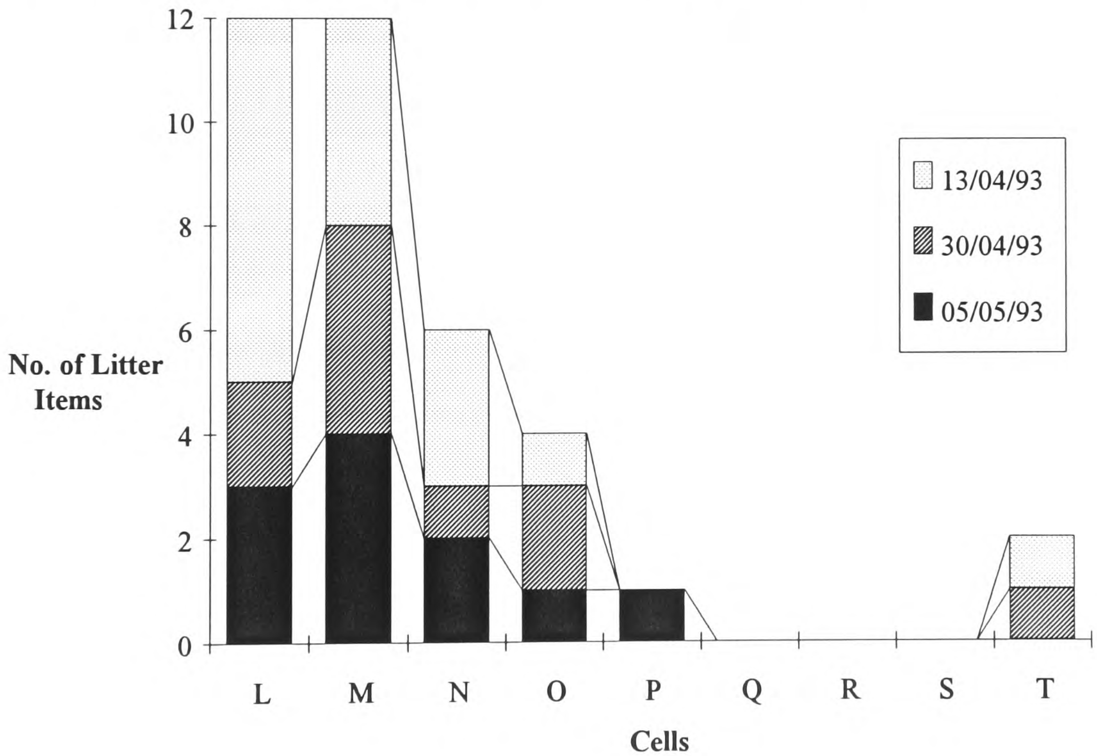
Figure 7.11. Losses of Litter from Sprayed Cells



Indeed, losses during the first and second monitoring periods were not accounted for within any downstream cells in the survey area. This meant that items moving during this period must have travelled at least 45 m to go unrecorded. This tendency towards large distance movements was also confirmed by the lack of movement recorded between sprayed cells. It was initially considered that losses from the uppermost cell (H) could result in increases in sprayed items in the other three cells (I, J, K) with time. However, this small-scale movement did not occur.

It was only at the third monitoring time (April 13^{th} 1992) that downstream movement was recorded within the site area (Fig. 7.12). Seventeen items were found between cells L to T, all of which were either plastics or feminine hygiene items. This constituted the greatest deposition within the site during the monitoring period and also coincided with the highest flows recorded since marking the litter (13.44 cumecs). In subsequent surveys, numbers declined in downstream cells. Although litter items had travelled as far as cell T, the three upstream cells Q, R, S contained no marked material. This could be a result of random stranding of material or, possibly, due to differing site physical characteristics in these areas. During the monitoring period a total of 136 items were lost from the site. Plastics and feminine hygiene items accounted for almost all these losses, 85 and 21 items respectively. Despite such large losses from the site, the maximum number of items recorded downstream of the sprayed area at any one time was seventeen. It must therefore be concluded that plastic and feminine hygiene items were the most mobile litter types, and once dislodged they tended to move more than 45 m at one time. Indeed, it is possible that the mobility of these items could also have increased through wind action, although no attempt was made to quantify this factor within this research.

Figure 7.12. Movement of Litter Downstream of Sprayed Cells



Movements of litter between upper, middle and lower bank zones was minimal (Table 7.3). No litter from the upper bank was recorded in any other zone during the survey period. Mixing did, however, occur between middle and lower bank areas. The dominant direction was from the lower to the middle zone (13 items), whilst only a few items (3) moved in the other direction. This could be another reason for higher numbers recorded in this bank area.

Table 7.3. Litter Movement between Sprayed Zones

Survey Dates	Lower to Middle Zone	Middle to Lower Zone
4/3/93	0	0
23/3/93	0	0
13/4/93	5	2
30/4/93	4	1
5/5/93	4	0

In summary, litter movements appear to be greatly influenced by flow regimes and site physical characteristics. Flood events result in large-scale litter movement, particularly by mobile litter groups such as plastics and feminine hygiene items. The level of flooding is directly related to litter movement and deposition, with larger floods causing the greatest deposition. Transportation tends to be long distance, with most deposition occurring in the mid-bank zone. Deposition continues for some time following a flood event and gradually levels off with time. Accumulation tends to stabilise at this point until the next flood event. Results were obtained from limited geographical areas and as such should not be applied to the entire catchment. The studies did, however, provide a basic understanding of litter movement mechanisms.

3) River/Beach Interface

Introduction

Marine litter has been stated as originating from three major sources, "land, vessels and beachgoers" (Pruter, 1987, p305). Marine litter is a generic term for all litter in the sea and does not relate to any particular source. Contrastingly, beach litter consists only of litter deposited on the beach face, either as a result of direct deposition by beach-users, or by indirect stranding of marine litter. Beach litter at any point in time may represent an accumulation of certain deposited material with time, and in this way does not directly reflect marine litter composition.

Although ocean dumping and beach-user discards have been widely researched, very little work has been carried out regarding land-based sources, i.e. sewage and riverine-derived litter. The Tidy Britain Group (TBG) has collected vast quantities of data on UK beaches through their Marine Litter Research Programme. From this programme, a typical litter profile typical has been produced for the UK/Irish Sea area, based on characteristics such as material composition and origin, which were consistent within this area.

Riverine litter does not possess the same compositional profile as other marine litter sources. For example, containers are not prominent riverbank components, unlike in marine areas, where they are abundant and act as valuable sources of information. This disparity in profiles was considered to be a potential means of assessing riverine contributions to marine litter. It was considered that litter profile comparisons of beaches with no riverine inputs and those with potential inputs could show significant differences attributable to the existence of riverine components. The Bristol Channel provided a suitable study area to test this hypothesis due to the abundance of potential riverine sources, and the limited nature of other marine litter sources, i.e. shipping and oceanic inputs. To link into the TGB's database, beaches were assessed using TBG survey forms (Appendix A4), to allow direct comparison with TBG data on open-sea beaches .

Method

Study areas were chosen within the Bristol Channel in both S. Wales and N. Devon/Somerset. Selected sites were in areas surrounding the rivers assessed for the baseline survey, and were approximately opposite one another in the channel. Low energy, preferably sandy beach types, were required with wide reach zones and multiple strand-lines, to create the optimum conditions for litter deposition (Dixon & Dixon, 1981). Within the S. Wales area, the predominance of pebble beaches limited the number of suitable sites to four (West Aberthaw, Llantwit Major, Southerndown, Merthyr Mawr). This selection was based on prior knowledge of litter accumulation within the area (Simmons & Williams, 1993). In the N. Devon/Somerset region, eight beaches were selected (Lee Bay, Lynmouth, Porlock, Minehead, Dunster, Blue Anchor Bay, Watchet, Doniford), to ensure that there was sufficient data. However, these tended to be small pocket beaches with lesser litter deposition, creating a need for greater site numbers. It was intended to make regional comparisons of litter compositions so differences in actual numbers were not important.

A total of 32 site assessments were carried out in both summer and winter after onshore winds had prevailed for some days, using techniques developed by Dixon and Dixon (1981). At each site, three 5 m wide belt transects were established, extending across the foreshore to encompass all strand-lines. Within these transects quantities and types of non-container litter were recorded. To obtain container results more extensive sampling was required in the form of strand-line surveys along approximately 1 km on each beach. Within this area information was recorded on containers regarding, if possible, fabrication material, size, colour, original contents, age and geographical origins. In both cases, S. Wales and N. Devon/Somerset data sets were combined to include all sampling times and all beaches within each region, giving overall compositions for the two regions. Where possible, results were compared with those collected as part of the TBG's National Shoreline Survey between 1979 and 1988 (Irish Sea Study Group, 1990).

Results and Discussion

Fabrication materials were first compared for the different survey areas (Table 7.4). Higher proportions of plastic containers recorded in this survey were possibly a result of increasing trends towards the use of plastics packaging. The very high numbers of plastic containers found on Welsh beaches was, however, rather more difficult to explain. It is possible that a link exists between these high numbers and riverine inputs. Depleted numbers of less resilient packaging material, such as glass, may also result from fragmentation, a likely prospect in a high energy area such as the Bristol Channel.

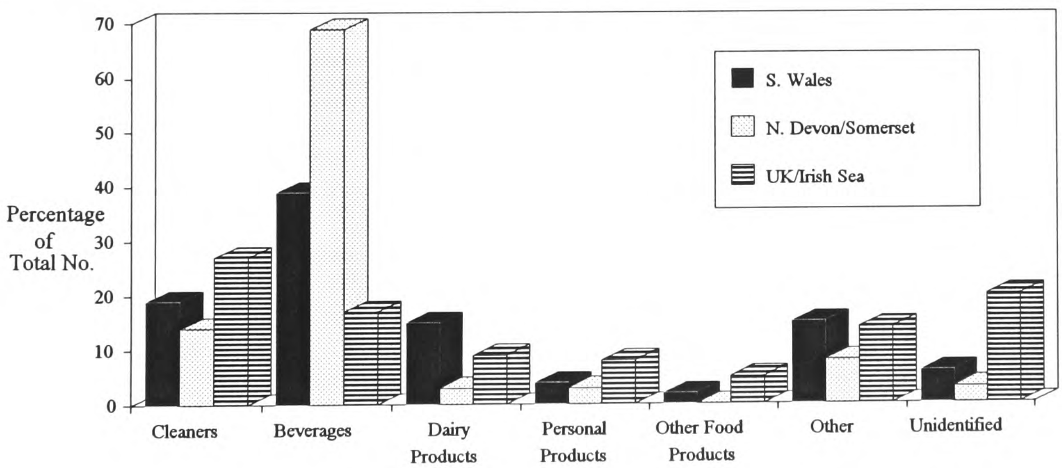
Table 7.4. Container Fabrication Materials

	Percentage of Total Numbers		
Fabrication Material	**S. Wales**	**N. Devon/Somerset**	**UK/Irish Sea**
Plastic	82	58	51
Metal	17	40	37
Glass	1	2	8
Other	0	0	4

Although the riverine pilot and baseline surveys recorded few plastic containers, it is feasible that their numbers were low due to short bank residence times. Plastics containers were noted at riverine fly-tipping sites, but their presence was seldom recorded elsewhere. It is plausible that inputs occur from these sites, but once removed from this input source, containers travel large distances due to their buoyant physical characteristics and low stranding potential. In this way considerable numbers of plastics containers of riverine origin may end up on beaches without interim recording. Two other observations corroborated this theory. Firstly, during high flow conditions, containers were often observed being carried in the river flow but no increases were recorded at survey sites when water levels receded, suggesting transportation to sea; and secondly, plastic containers were considered to be DIY-related, for example interior paints, herbicides and carpet cleaners. Such items were thought unlikely to have originated from either shipping vessels or beach-users and thus were likely to be of riverine origin.

A comparison was then made for original contents of plastic containers, between data sets (Fig. 7.13). These results also varied considerably from the UK/Irish Sea data set (Irish Sea Study Group, 1990). A switch occurred away from a predominance of lavatory and household cleaners towards greater numbers of beverage containers. The assortment of cleaning materials are believed to have originated from shipping sources and the Irish Sea Study Group (1990, p52) concluded that "approximately 50% of containers were believed to originate from ships discharges, and the remainder land-based sources, primarily holiday makers". This does not appear to be the case in either the S. Wales or N. Devon/Somerset regions. The higher numbers of beverage and dairy product containers tend to indicate greater contribution from land-based sources, either by beach users or riverine inputs. This result is not surprising considering the Bristol Channel's estuarine nature, the comparative lack of shipping, and the unlikely occurrence of oceanic inputs

Figure 7.13. Original Contents of Plastic Containers



Analysis of container origins indicated ship discards were less prominent in the Bristol Channel survey areas. In fact, no foreign material was found in the N.

Devon/Somerset assessments. A contributory factor for this outcome is likely to be the predominant south-westerly wind direction within the channel. Litter movements and deposition are known to be most affected by wind direction and force (Dixon & Dixon, 1981), making the S. Wales coastline more prone to deposition. In S. Wales, 93% of plastic containers were manufactured or marketed in the UK (Table 7.5), a considerably higher proportion than indicated in the UK/Irish Sea data set (63%). All foreign material found on Welsh beaches was European, most of it from France. This lack of diversity in origins again inferred low levels of ship discards.

Table 7.5. Geographical Origins of Plastic Containers

Origin	**S. Wales (%) n=392**	**N. Devon/Irish Sea (%) n=4396**
United Kingdom	93	63
France	2	3
Germany	0	2
Rest of Europe	1	8
Benelux	0	2
Rest of World	0	2
Unidentified	4	20

Non-container results could not be directly compared to the Irish Sea Study Group (1990) data, as findings were reported as percentage occurrence at all sites. Too few sites were surveyed within S. Wales and N. Devon/Somerset to meaningfully present results in this manner. Instead results are given as percentages of total numbers found in each region (Table 7.6). The most frequently occurring items in the UK/Irish Sea study were also the most numerous in S. Wales and N. Devon/Somerset; namely plastic fragments, bags and plastic sheeting. Interestingly, plastic bags and sheeting were proportionally found in far higher numbers on Welsh beaches than those in N. Devon and Somerset.

It is postulated that high plastic bag/sheeting numbers could result from riverine inputs. This theory is based on the known high mobility of such material (Chapter 7), and the relative lack of accumulation on river banks. Also, unusually high amounts of plastic have been found within the Bristol Channel (Williams et al, 1993b). This problem has developed to such an extent that fishermen are claiming it constitutes a significant threat to their livelihood (North Devon Advertiser, 1992; North Devon Gazette, 1992). With inputs of this material from ship discards and beach users likely to be minimal, it is not an unrealistic suggestion that such material has originated from rivers. Circulation patterns and slow flushing times within the Bristol Channel are likely to result in long residence times before this material is released into the open sea. The Channel may therefore act as an eventual sink for plastic sheeting and other mobile materials. If inputs of such material continue, a build-up within the Bristol Channel may occur with resulting consequences.

Table 7.6. Proportional Composition of Non-Container Material

Litter Type	S. Wales (%)	N. Devon/Somerset (%)
Paper	0	2
Cardboard	0	1
Plastic Fragments	37	46
Plastic Bags/Sheeting	21	5
Glass	0	0
Metal	2	4
Wood	13	3
Oil	0	0
Shotgun Cartridge	0	2
Raw Sewage	12	2
Fishing Net	2	1
Fishing Line	2	7
Rope	2	2
Wire	0	3
Clothing	2	6
Paper/Plastic Cups	0	4
Confectionery Wrapping	7	9
Other	0	3

Overall, surveys within the Bristol Channel produced profiles that differed from the UK/Irish Sea data set. More research is needed to conclusively prove that these differences were a direct result of riverine inputs, but this work has made a step towards highlighting the importance of river/beach interfaces in fully understanding beach litter problems.

CHAPTER 8

PLASTIC DEGRADATION

Background

One particular aspect of riverine litter which appears to cause great aesthetic offence, resulting in public complaints, is the stranding of plastic sheeting along the length of South Wales rivers (Keep Wales Tidy Campaign, 1992; SW Echo, 1991). The "flashy" nature of rivers in S. Wales and resultant flow fluctuations allow litter items to be transported considerable distances until suitable obstructions, often vegetation, filter the litter. Physical characteristics of some litter items allow them to become entangled in the vegetation and be stranded when the water level recedes. The resulting "Christmas Tree" adornment of items (Plate 3.2), predominantly plastic sheeting, is a common occurrence, becoming more conspicuous as water levels lower, and during winter months when lack of foliage offers less camouflage.

Results from the pilot study (Chapter 3) identified polyethylene sheeting as a major component of riverine litter causing offence by stranding. It was found to be both abundant and diffuse along the River Taff's length. Initial studies investigating litter inputs failed to indicate any major point source contributions of plastic sheeting. Source identification was further complicated by large variations in type and potential end-use of such plastics. A possible reason for polyethylene abundance and widespread distribution was thought due to the inherent longevity of such material and hence its accumulation potential. In order to address this possibility, more information was required regarding the lifetime of plastic sheeting under environmental conditions. To gain such information, exposure trials were carried out using samples of polyethylene sheeting and monitoring degradation by means of tensile testing (Onions & Rees, 1992).

One particular polyethylene product commonly found along river banks, the sanitary towel backing strip, was deemed appropriate for investigation. Not only does this product contribute to the overall aesthetic nuisance of litter, but also impinges upon broader issues such as health and safety which need to be considered. The sanitary towel market is expanding, even by 1990 the sanitary protection split between towels and tampons was 56% to 44% (Howarth, pers comm). With the recent introduction of daily use panty liners, contributing 28.3% of the total (Howarth, pers comm), towels obviously constitute a waste disposal problem. Smith and Nephew Products Ltd, estimated that 72% of all towels are flushed (Howarth, pers comm) and, with the still largely archaic and ineffective screening in UK sewerage systems, their contribution to riverine plastic as a whole could be fairly substantial. In light of these facts, panty liner backing strip degradation trials were initiated.

Plastics - Structure and Mechanical Properties

"Plastics can be defined as organic materials containing molecules of high molecular weight (i.e. between 10^4 and 10^7) which can be moulded to shape by the application of pressure at moderately high temperatures. Once moulded they may retain their plasticity in the manner of polyethylene or nylon (thermoplastics) or they may become permanently hard and brittle like bakelite (thermosetting plastics)" (Higgins, 1988, p243).

Until the beginning of the twentieth century emphasis was placed on the destruction of complex organic compounds to produce larger numbers of simpler materials. It was only then that chemists learnt to rebuild some of the products of destructive processes to produce substances which did not occur naturally. Of major importance amongst such substances produced were the super-polymers (plastics). The cracking of heavier oils during petroleum refinery to produce light volatile hydrocarbons, such as octane, gave rise to the by-product ethylene (C_2H_4). The double bond between the carbon atoms with the ethylene may be broken when suitably treated, resulting in a large number of the units forming and linking up (polymerising) into a long chain-like molecule, producing the plastic - polyethylene.

Vinyl compounds, are ethylene based, but with one or more of the hydrogen atoms replaced by a different atom or group. Typically, vinyl compounds may exist as mobile liquids, flowing as easily as water due to weak van der Waals forces between the relatively small molecules (van der Waals forces are the secondary electrostatic forces which give rise to attraction between any one molecule and its neighbour). Initial polymerisation results in molecules of a size where van der Waals forces become effective, producing a more viscous liquid. Eventually, the molecules become so long that the van der Waals forces between adjacent molecules are of a strength to constitute a solid material. The material remains in this state unless an increase in energy of the molecules, for example by heating, is great enough to overcome the forces between them. The capability of repeated softening of the material with the application of heat resulted in them being named, thermoplastics.

The polymer properties discussed above, explain the reason why plastic deformation is very temperature dependent. Increased temperature diminishes the secondary electrostatic forces causing slippage to occur more easily between adjacent chains. Polymer deformation is also time-dependent, i.e. the molecular response to reach equilibrium with external forces is slow, causing indefinite deformation of material even after the removal of the external forces.

Two principal modes of deformation occur in super-polymers with the application of stress. Atoms may be displaced relative to one another when two atoms within a chain are fixed by covalent bonds. This elastic type deformation allows for immediate return of atoms to their original position once stress has been removed. Straightening of coiled and folded chain molecules may also occur in the stress direction. This distortion is also reversible upon the removal of stress and so is similarly classified as elastic deformation. In regions of the thermoplastic where molecules are merely attracted to one another by weak van der Waals forces, they may slip into new positions relative to one another. This "plastic" deformation is permanent. Elastic deformation accounts for much of the initial distortion of plastics under stress, as the straightening of molecules tends to occur more rapidly than slipping.

Degradation of Plastics

"Two general mechanisms are usually considered for degradable plastics, namely photodegradation and biodegradation. Unfortunately, care is not taken to define which mechanism is involved in a particular process with a degradable plastic and the two have come to be used almost interchangeably. There is frequently a tendency to presume that plastics degrade virtually completely by biodegradation. However, in most instances photodegradation is the major process involved" (Klemchuk, 1990, p188).

Photodegradation is the process by which ultra-violet light (sunlight) reduces the molecular weight of polymers, causing the plastic to become brittle and disintegrate. This process may only occur through two possible mechanisms, photo-oxidation and ketone photolysis. Photo-oxidation results when covalent bonds form between the oxygen atoms of adjacent molecules. These covalent cross-links inhibit slip between chain molecules, causing the plastic to become harder and more brittle (Higgins, 1988). This photodegradation process may be inhibited by adding carbon black to make the material opaque, or more commonly, by adding an anti-oxidant such as a phenol or amine. Photodegradation by ketone photolysis occurs when ketones are introduced to the backbones of polymers by photo-oxidation. These ketones absorb photons of appropriate energy when exposed to light and subsequently break the polymer backbone. This form of photodegradation also results in the embrittling of plastic, as the smaller molecules produced do not contribute as effectively to the polymer's physical properties.

Contrastingly, biodegradation may be defined as the "breakdown of the physical and chemical properties of a structure by the action of living organisms - typically fungi and bacteria" (Lloyd, 1987, p20). Many studies have been undertaken to explore the biodegradation of plastics (Nykvist, 1974; Klemchuk, 1990; Lloyd, 1987). A common method used to monitor rates of plastic decomposition is the use of radioactive isotopes. Nykvist (1974) studied polyethylene containing the radioactive isotope ^{14}C. The isotope decomposes into a nitrogen atom and an electron (beta radiation), the latter allowing measurements to be made in the form of counts/min/gramme. Results indicated that polyethylene is not biodegradable unless its chain length is substantially reduced. Klemchuk (1990, p183) showed agreement with this theory in his review of degradable plastics in which he stated "that all commercial packaging plastics are not biodegradable, because their molecular weights are too high and their structures are too rigid for assimilation by organisms".

An important study by Potts et al (1972) found most commercial thermoplastics to be immune to fungal attack. Although polyethylene film did initially support growth, this was apparently due to additives, as no growth occurred when removed. It was in this study that the role of molecular weight in the biodegradation process was shown. Results indicated that straight-chain hydrocarbons with a molecular weight of greater than 500 cannot support fungi, whilst branching even at MW 212 prevented fungal growth. Samples of low density polyethylene were found to support fungi, only after their molecular weight had been significantly reduced by pyrolysis. Klemchuk, (1990, p195) in agreement with the above work claimed that "unless polymers are first photodegraded to low molecular weights, virtually no biodegradation can take place. Even so, the degree of biodegradation after photodegradation to relatively low molecular weights is not encouraging for complete biodegradation of the polymer samples in 1 - 2 years".

Longer term studies of between two and eight years soil burial, showed that polymer losses of between 1% and 3% were the most that could be expected. Seal (1988) considered these losses to be due to low molecular weight contaminants in the polymer which may be readily degraded, and possibly the presence of isolated double bonds in the carbon chain resulting from side reactions. It was concluded that after exposure to UV-light, biodegradation of the remaining polymer was not enhanced, but that the smaller molecules produced by photo-oxidation were the only biodegradable element which could decompose to give the overall polymer loss.

The lack of naturally occurring biodegradation of plastics has stimulated intensive research with a view to producing truly biodegradable polymers. Although polyethylene plastic has been manufactured which exhibits increased photochemical oxidation and therefore fragments quicker, the packaging cannot be considered truly degradable until fragments undergo further decomposition to components which may recycle in nature.

Onions and Rees (1992), in their investigation of photodegradable Hi-Cone carriers (4/6 pack holders) in the marine environment, demonstrated that use of photodegradable plastic resulted in earlier embrittlement and fragmentation. Tensile testing was carried out on samples of conventional and photodegradable Hi-Cone carriers after various exposure trials. Ultimate embrittlement (reduction to 5% elongation) of the photodegradable samples was reached after only 74 days in the UK, whilst no reduction in elongation was recorded for the conventional carriers. Tensile testing, as a measure of degradability, produced conclusive results in the Hi-Cone study. The benefits of this uncomplicated test procedure and its application to environmental trials led to its adoption for use in this research as a measure of polyethylene degradation in riverine environments.

Test Material

The test material used was a brand of panty liner marketed as a daily use towel. Panty liners generally consists of a (nonoven polypropylene/polyethylene/rayon) cover enclosing cotton pulp which is backed by a polyethylene shield. A strip along the shield is coated with pressure-sensitive adhesive and covered with a silicone-coated release tape. The release tape is removed upon initial application and generally the remaining product is then flushed, intact, after use. The towel is then transported by the sewerage system to a sewage treatment works, where appropriate treatment is carried out. Final effluent may be discharged to inland waters or sea and the sludge to the land, sea or atmosphere. Unfortunately, during the sewage treatment process there is a tendency for the plastic backing strip to become dissociated from the cotton pulp. In this form the strips constitute a major screening problem. "Certain types of plastics and cotton bud sticks appear to align themselves so that they give least resistance to flow and as a result a higher proportion get past the screens than would be expected" (Huntingdon, 1990, p 3). In this manner, even under optimum conditions, sanitary towel backing strips often find their way into watercourses. This problem is exacerbated during periods of heavy rainfall as flows during storm conditions have to be discharged after only coarse screening (often 12-25 mm bar screens) unless suitable storage facilities exist. Concurrently, under the same conditions, Storm Water Overflows also operate, commonly discharging completely unscreened effluent into receiving waters. Once present in the watercourse, it is generally only the plastic backing strip of a sanitary towel which persists. As such, tensile testing of just the backing strips was felt appropriate.

Method

Before instigating degradation trials under environmental conditions, control samples were required in order to develop appropriate methods for test piece preparation and optimum test parameters. To obtain the test pieces, release tapes were first removed from each of the panty liners. These were then submerged in water for 1-2 days until separation of the backing strip from the cotton pulp could be achieved without damaging or stretching the test material.

Guidelines exist regarding standard tensile testing procedures for plastic sheeting (ASTM D882-83, 1983; BSI 2782, 1986). These guidelines were followed within the limitations of the test specimen. A strip was cut from the centre of the specimen, of a width which would conform with the standard testing procedure (19.15 mm). A steel rule was used as a template, and using a scalpel, clean parallel edges were cut along the length of the backing strip (150 mm). Following BSI 2782 (1986) recommendations, tensile testing was carried out at a variety of speeds, initial gauge lengths (distance between grips), grip types, and loads. Due to the unique nature of the test piece, a trade off was required between these factors in order to produce the most consistent results. After several trials and discussions with materials experts (Wild, pers comm) the test parameters were finally set. Under these constant conditions, twenty control specimens were tested with which samples could be compared after exposure.

Panty liner degradation trials were initiated, using ten test pieces to be measured per unit time, a number felt to be suitable based on the BSI 2782 (1986) recommendations of a minimum five test pieces per sample. Having separated the backing strips from the remainder of the towel, these were secured to hardboard exposure plates in sets of ten, using carefully placed drawing pins. The hardboard plates were then tethered to fixed objects on the river bank with durable garden wire (Plate 8.1), and removed for analysis at regular intervals.

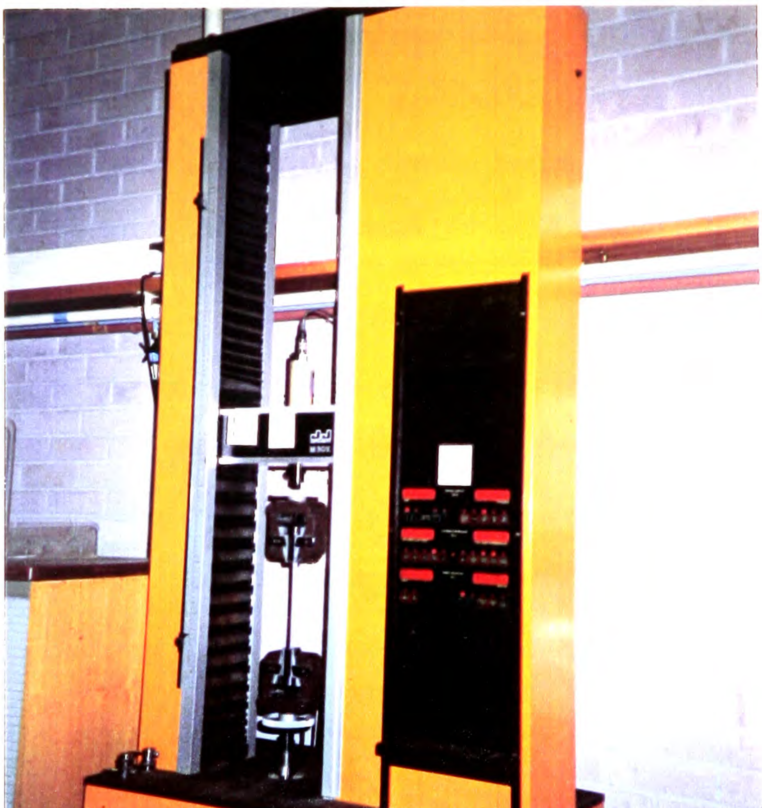
Test Procedure

A JJM30K tensile testing instrument was used for the degradation analyses (Plate 8.2). It became immediately obvious that the instrument's standard gnurled grips were unsuitable for the test material as they were causing tear failure at the grip interface. This problem was overcome by lining the grips with rubber.

The digital displays were programmed to the chosen settings (maximum load 0.1 KN, maximum extension 500 mm, grip separation speed 25 mm/min) and the plotter linked up to produce a graphical printout. The grips were then set to the initial gauge length (90 mm) and specimens marked to ensure the test was carried out using the test piece's centre. Once the specimen was properly aligned and both the tensile instrument and plotter zeroed, the test was initiated. The grips then pulled apart at a constant rate of 25 mm/min whilst the digital displays monitored the increase in load and extension. When specimen failure occurred, digital outputs for maximum load and extension were recorded, along with the extension at yield point ("first point on the force-extension curve at which an extension occurs without an increase in force"; BSI 2782, 1986, p2). This procedure was repeated for each of the ten specimens in the sample and for each subsequent sample of ten test pieces.

Plate 8.1. Panty Liner Degradation Trial Samples

Plate 8.2. JJM30K Tensile Testing Apparatus



Pilot Trial

Initial degradation trials were set up for a six week period based on a weekly sampling programme. Attachment height for exposure plates was governed by the level of indigenous litter stranding, i.e. previous flood level. In this particular case, three exposure plates were secured to the bank, whilst the remainder were attached to nearby branches. All strips were positioned at a natural stranding level, and were therefore, as far as possible, being exposed to equivalent environmental conditions as those stranded naturally (Plate 8.2).

Results and Discussion

Beneficial properties of plastic products such as durability and strength have led to their widespread use in society. Plastics are expected to retain these properties throughout their service lifetime in order to fulfil their required function. Specific mechanical properties may be measured to predict material durability, aiding determination of potential applications, and may also act as a reference with which to monitor the breakdown of plastics. Tensile testing of materials to record load/extension measurements allow mechanical properties such as tensile strength and elongation to be calculated.

Tensile strength is "the maximum tensile stress which the test piece is capable of supporting" (BSI 2782, 1986, p3). Results are dependent on the individual characteristics of a material, and are usually sensitive to changes of polymer molecular weight (Wypych, 1990). Tensile strength maybe calculated using the equation:

$$\sigma = \frac{F}{A}$$

Where: σ = maximum tensile strength (MPa)
F = maximum force (N)
A = Initial mean cross-sectional area (mm)

Elongation is "the elongation produced in the gauge length of the test piece at break" (BSI 2782, 1986, p2) and is expressed as a percentage of the original gauge length. Percentage elongation at break may be calculated using the equation:

$$Ep = \frac{I - Io}{I} \times 100$$

Where: Ep = percentage elongation at break (%)
I = elongation in gauge length at break (mm)
Io = original gauge length (mm)

Elongation retention is largely dependent on polymer type and composition. "Relative to tensile strength, the elongation appears more sensitive to changes occurring during photodegradation" (Wypych, 1990, p251). Wypych (1990) also noted that no correlation existed between tensile strength and percentage elongation. Elongation was shown to be more indicative of changes in the amorphous phase, whilst tensile strength was more dependent on crystalline polymer regions.

Other parameters such as break factor[1] and percentage elongation at yield[2] were also calculated, but were so similar to the more common measurements of tensile strength and elongation at break respectively, that they allowed no further interpretation of the results. Sample means were calculated for each parameter, together with two-sided confidence limits of the mean. The confidence limits "give an interval in which the true mean is expected to lie with specified confidence" (Gilbert, 1987, p137) in this case 95%.

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[1] Maximum load divided by minimum width.

[2] Elongation produced in gauge length of the test piece at yield stress (first marked inflection of the stress/strain curve) expressed as a percentage of the original gauge length

Results of tensile strength and percentage elongation at break, for the six week exposure period, did indicate some degradation had occurred (Figs. 8.1 & 8.2). Significant decreases in values were seen between control samples and those tested after one week. Subsequent weeks, however, showed little further degradation. Confidence limits were predictably greater for exposed samples than controls, as a result of material variations brought about through exposure. Although mean values differed from the second to the sixth week, at all times confidence limits overlapped making predictions of any further degradation inconclusive.

Weekly samples were removed from the bank for the first three weeks, primarily for ease of access reasons, followed by those suspended from vegetation. The slight rise in both tensile strength and elongation values for the suspended samples, after an extended exposure period, raised the possibility of differing degradation rates resulting from variations in stranding position. Consideration was given to the possibility that bankside samples may have been subjected to greater physical weathering from contact with earth and vegetation on the bank. Physical abrasion in this manner could be the cause of flaws in the material, resulting in a lowering of tensile property values. It was noted during the tensile testing that test pieces within samples showed a wide variation in their response to tensile stress. Some test strips, even after exposure, reacted in a similar manner to control samples, whilst others failed very prematurely. The premature failure seemed to initiate from a defect within the strip. These two very different responses resulted in a very broad range of results for samples, as indicated in the confidence limits. Further speculation regarding degradation was limited due to the short exposure time, but it was felt that future trials should address this possibility. Having successfully shown degradation even over a short exposure period using the methods developed, a second trial was implemented for an extended period of four months and sampling the various stranding positions in parallel, on a monthly basis.

Figure 8.1. LDPE Degradation Trial (6 Weeks): Tensile Strength (Bar Represents 95% Confidence Limits)

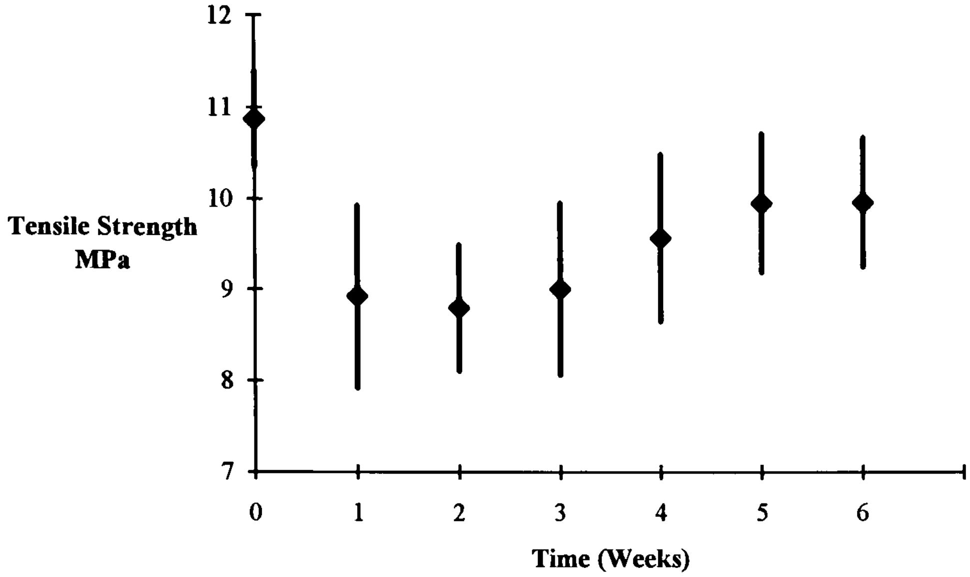
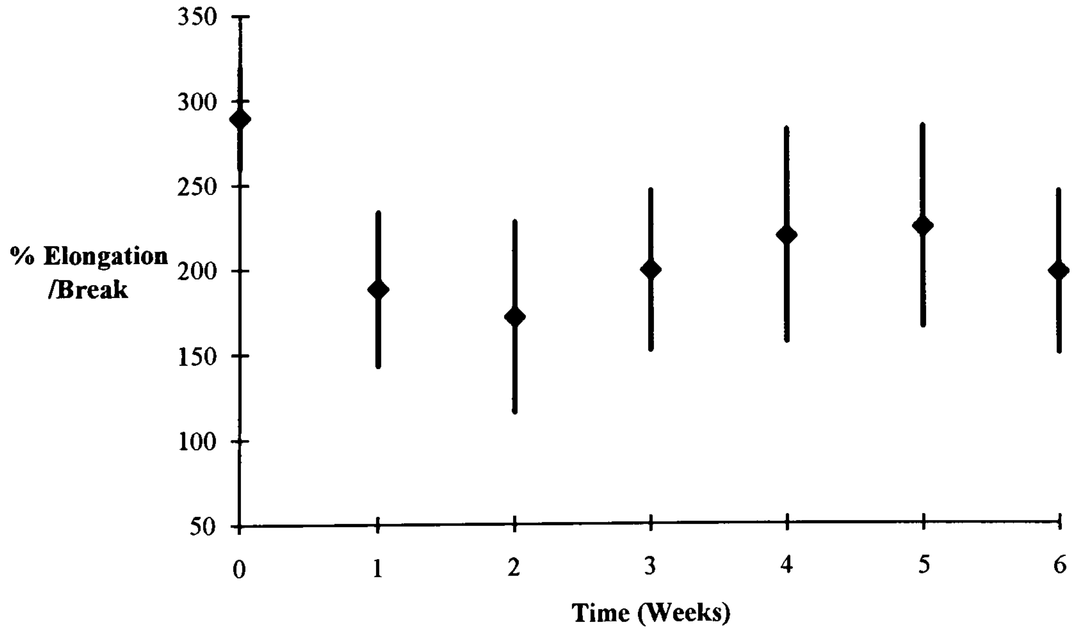


Figure 8.2. LDPE Degradation Trial (6 Weeks): % Elongation at Break (Bar Represents 95% Confidence Limits)



Degradation Trial - 4 Month Exposure

Exposure plates were prepared in the same manner as the previous trial with ten specimens per board. However, this time four boards were tethered to the bank, four suspended, and four were buried. The buried specimens were placed in a plant tray, and covered in river bank soil, in order to simulate the effect of plastic burial in the degradation process. Sampling intervals were extended to monthly, as after initial degradation, little change was seen on a weekly basis during the pilot trial. After each month, a set of ten specimens was removed from each of the stranding positions, and tested using the methods previously described. Results for suspended samples were recorded for only two months due to unfortunate removal of two boards during flood conditions (December 2^{nd}, 1992; 74.95 cumecs).

Results and Discussion

Measurements of both tensile strength and elongation showed that significant degradation occurred during the first month of exposure for bankside samples (Figs. 8.3 & 8.4). Subsequent months, however, indicated little change in the plastic's tensile properties, with confidence limits overlapping for each of the samples.

Figures 8.5 and 8.6 show a close relationship between bankside and suspended samples, which deviate from that shown by the buried specimens. The obvious differences in tensile properties of the specimens after burial are likely to result from sunlight exclusion. Other factors such as less physical abrasion must also be considered.

Slight decreases in tensile properties for the buried samples may have resulted from biodegradation. This process, however, would have been limited without prior breakdown by photodegradation. Extraneous results were recorded for both tensile strength and elongation of buried samples for the second month test results. No reasonable explanation could be found to justify this anomaly. However, when mean values are accompanied by 95% confidence limits (Fig. 8.7) it can be seen that overlap is present for all samples. Therefore, degradation is probably not significant from control samples.

Wypych (1990) discussed plastic degradation in relation to percentage retention of tensile properties such as strength and elongation. Figures 8.8 and 8.9 show results in this format for the three stranding positions. Buried samples showed the greatest tensile strength retention, dropping no lower than 90%, whilst bankside and suspended samples showed similar retention rates at approximately 80%. Based on the known relationship between decreasing molecular weight and decreasing tensile strength (Wypych, 1990), results appeared to demonstrate that some decrease in molecular weight occurred during the first month of exposure for bankside and suspended samples, but with little further loss. Reduction in molecular weight of these samples as opposed to the buried samples is likely to be due to photodegradation of exposed specimens. Slight decreases in tensile strength (molecular weight) of buried samples not exposed to photodegradation may be explained by losses of low molecular weight contaminants in the polymer which are easily biodegraded (Seal, 1988).

Figure 8.3. LDPE Degradation Trial (4 Months): Bank Samples Tensile Strength (Bar Represents 95% Confidence Limits)

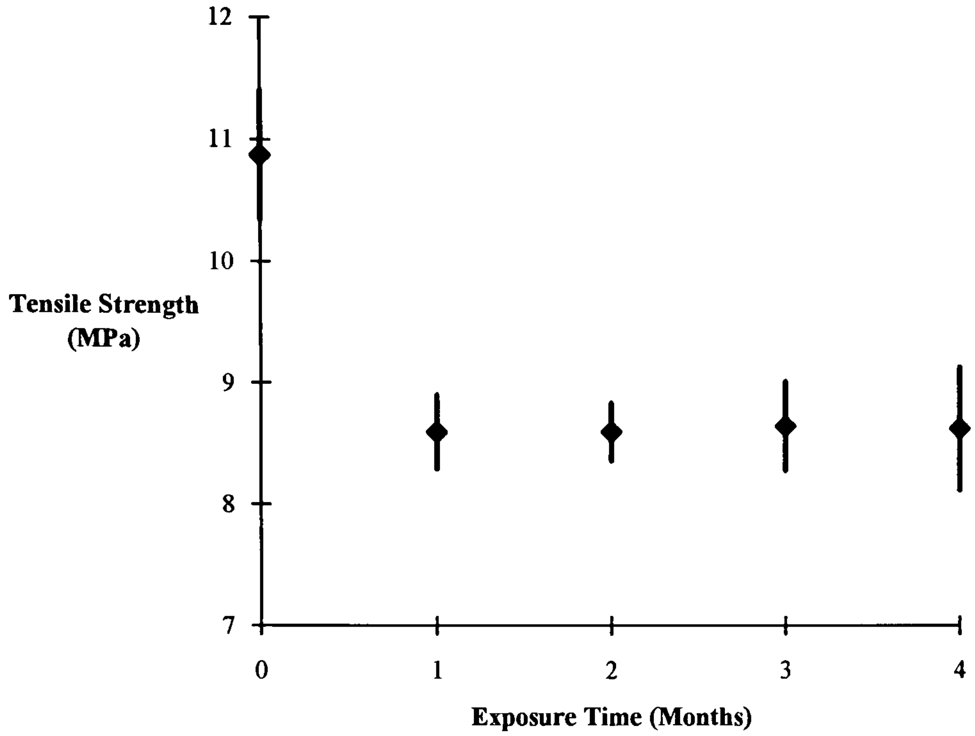


Figure 8.4. LDPE Degradation Trial (4 Months): Bank Samples % Elongation at Break (Bar Represents 95% Confidence Limits)

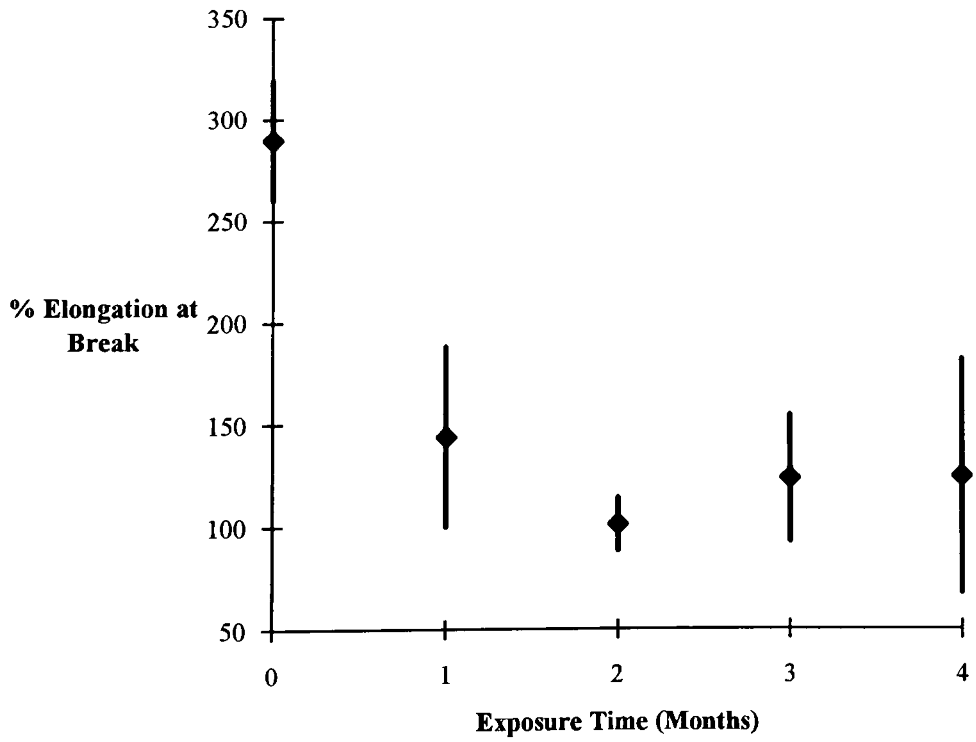


Figure 8.5. LDPE Degradation Trial (4 Months): Sample Tensile Strength for Three Exposure Areas (Bar Represents 95% Confidence Limits)

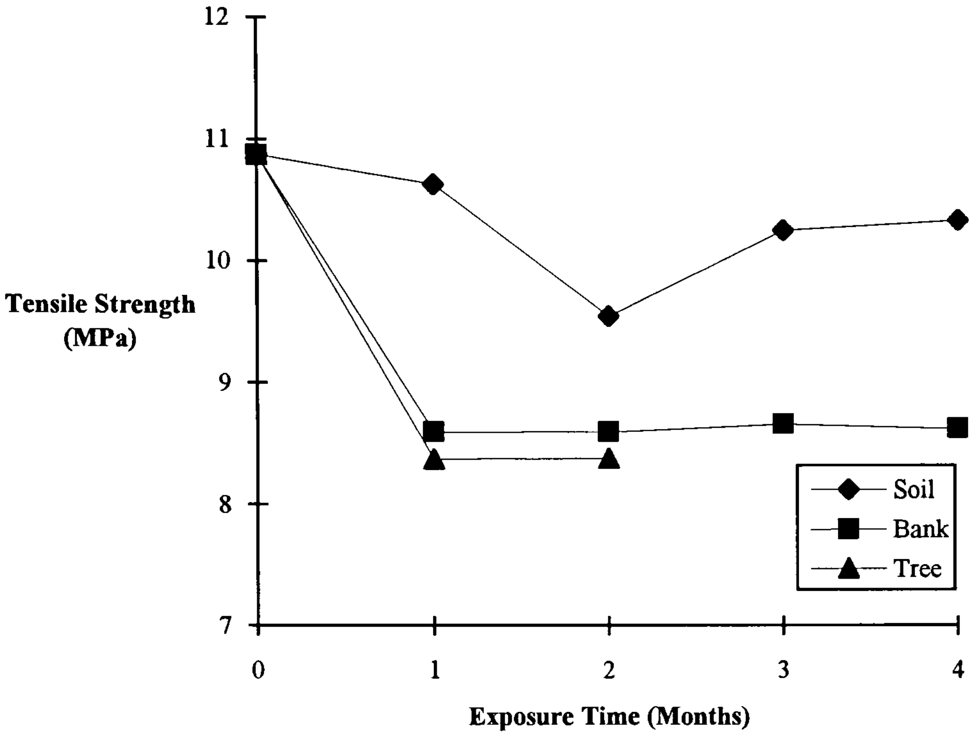


Figure 8.6. LDPE Degradation Trial (4 Months): Sample % Elongation at Break for Three Exposure Areas (Bar Represents 95% Confidence Limits)

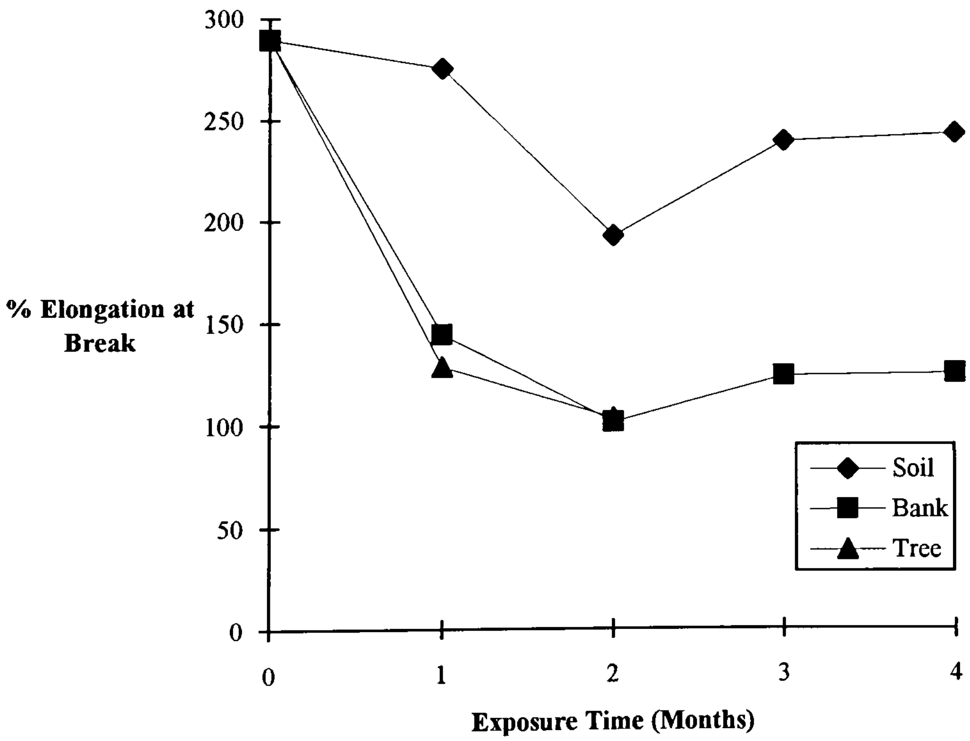
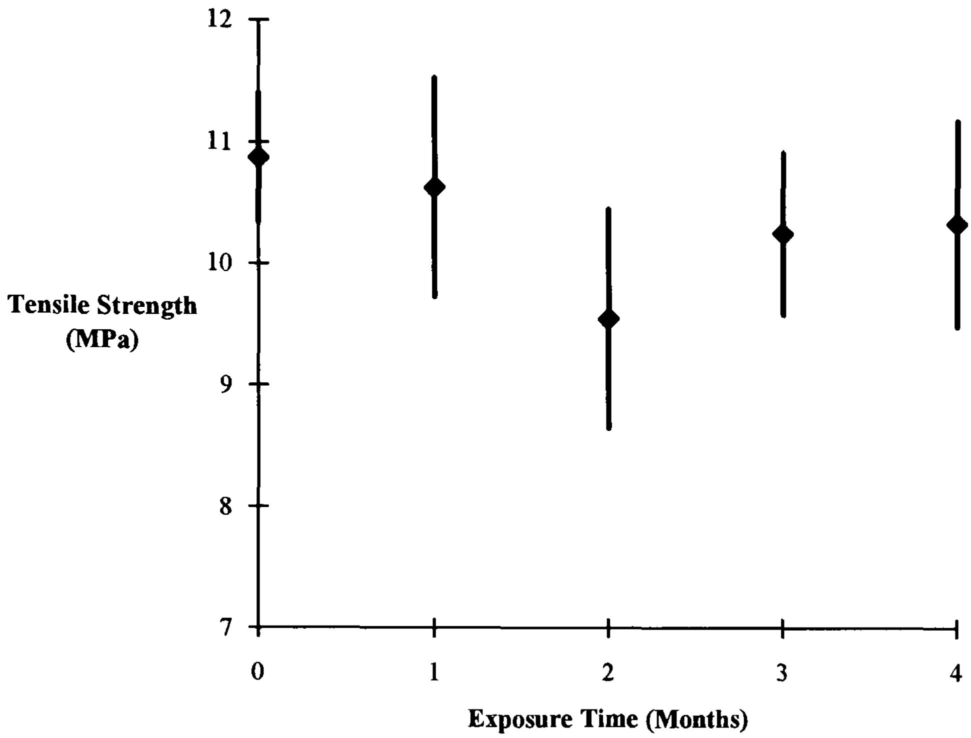


Figure 8.7. LDPE Degradation Trial (4 Months): Buried Sample Tensile Strength
(Bar Represents 95% Confidence Limits)



Although decreasing tensile strength may be related to reduced molecular weight, losses may be accounted for by photo or biodegradation, as seen above. More specifically, elongation retention is known to exhibit greater sensitivity to changes occurring during photodegradation and correlates well to chemical changes during photo-oxidation. Elongation retention results (Fig. 8.9) show retention as low as 35% for bankside and suspended samples, as opposed to 75% for buried samples, possibly indicating the overall importance of photodegradation in the degradative process. Overall, samples did not exhibit rapid degradation upon exposure to environmental conditions. Initial changes in physical properties were rapid, but were followed by little subsequent activity.

Figure 8.8. LDPE Degradation Trials (4 Months): Sample % Tensile Strength Retention at Three Exposure Areas

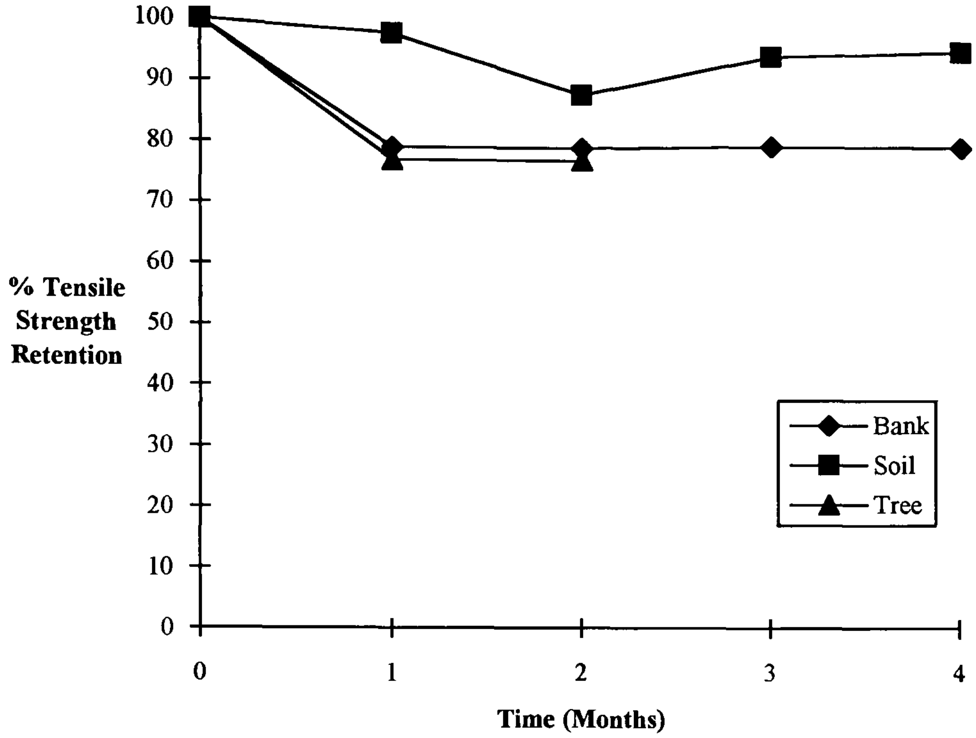
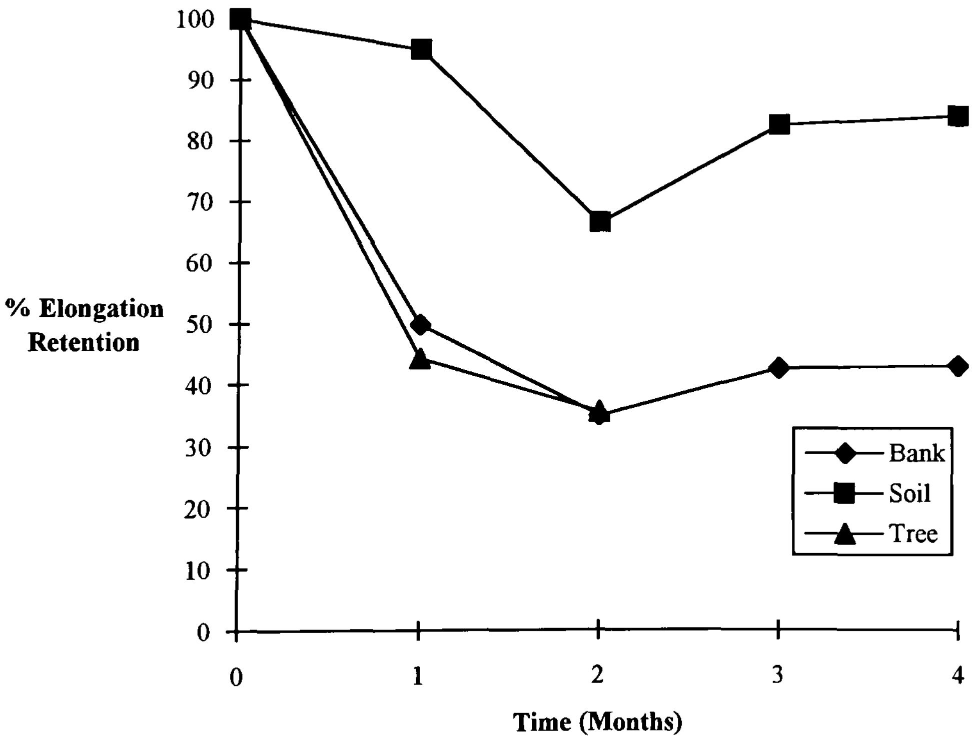


Figure 8.9. LDPE Degradation Trial (4 Months): Sample % Elongation Retention at Three Exposure Areas



Notes were made relating to sample appearance during this trial. Upon rinsing the samples after exposure, buried samples were shown to maintain their original appearance, whilst bankside and suspended samples exhibited obvious colour bleaching and dirt impregnation. Although procedures do exist with which to monitor colour bleaching within plastic film, these would have been too logistically problematical to carry out during the time-scale of this research, and are perhaps an area which could be investigated in future work.

CHAPTER 9

DISCUSSION

This research has taken the first steps towards understanding riverine litter problems, and developing scientifically rigorous assessment techniques. A survey method was devised to provide information on the scale of the problem at three river catchments; the Taff, E. Lyn and Avill. These surveys showed that the types of material present were indicative of certain sources, and allowed impact of certain river characteristics to be measured (Chapter 4). The baseline results, however, only showed a 'snap shot' of the litter problem at the time when sites were assessed. To realistically interpret results it was necessary to gain a better understanding of the processes governing riverine litter, by examining sources, pathways and sinks. Once again, pre-existing methods were not available to carry out analyses, and more novel approaches were needed. The studies devised provided valuable information which could be related back to baseline data. Whilst these study results have been discussed individually within the relevant chapters, a general discussion was considered necessary to the overall aim of the study to increase understanding of the riverine litter problem.

Sources

Two major litter sources were highlighted from the pilot and baseline studies (Chapters 3 & 4); fly-tipping and sewage inputs. These inputs were addressed in separate studies to gain a better understanding of frequency of inputs, composition, and quantities of litter from each source. Both had sporadic inputs, fly-tipping being related to anthropogenic factors, whilst sewage inputs were controlled by flood events. The composition from each source was distinctive, fly-tipping including a much higher proportion of plastic sheeting (53%) and textiles (19%). Sewage inputs were made up of large volumes of toilet paper, faecal matter, cotton material and food (57%), but with sanitary towels forming the most numerous sewage item. A rather anomalous sewage-related item was the napkin liner, which was only found once in all the sewage samples, whilst its presence was noted on several occasions at fly-tipping sites. Sewage samples showed that only the smaller plastic sheeting were introduced to the river via SWOs. The main contributor of plastic sheeting was therefore also likely to be fly-tipping sites. The greatest impact SWOs appeared to have in terms of river litter was to contribute persistent feminine hygiene products.

Pathways

Chapter 7, addressed aspects of litter movement in a variety of ways. The clearance site provided valuable information on litter accumulation and movement, and showed a distinctive correlation between flood events and litter movement. Introductions of litter outside of channel deposition (diffuse sources) were limited in the area monitored. A rise in litter deposition occurred for some time after flood events, with the main accumulation occurring in the mid-bank zone. As only some litter types have an increased input during flood events, e.g. sewage-derived material, then accumulation of other litter types, e.g. plastic sheeting at certain sites, could be due to their redistribution throughout the catchment. Baseline data (Chapter 4) showed a positive correlation between litter stranding and vegetation density. It would seem likely therefore, that during high flows litter is removed from sites with little restraining vegetation and becomes deposited in areas where the stranding potential is high.

In-flow measurements (Time of Travel, Chapter 7) indicated that litter stranding was prominent even in very high flows (74.59 cumecs). It also appeared that smaller items, such as feminine hygiene products, were more susceptible to stranding than larger pieces of plastic sheeting. This was confirmed by the baseline study which showed increased numbers of sewage items in the vicinity of SWOs. If these items were highly mobile, detection of accumulations of sewage-related litter would be impossible in these areas.

Sinks

River/beach interface processes were discussed together with other movement patterns (Chapter 7). Litter profiles within the study area were shown to differ from those in the UK/Irish Sea. Reduced amounts of foreign material (7%) were found compared with UK/Irish Sea data sets (37%), indicating lower levels of ship-discarded waste in the vicinity. Exceptionally high numbers of plastic containers recorded on S. Wales beaches were thought to have originated from riverine sources. Their contents were not comparable with those from UK/Irish Sea profiles, and consisted of a high proportion of land-based DIY-related items.

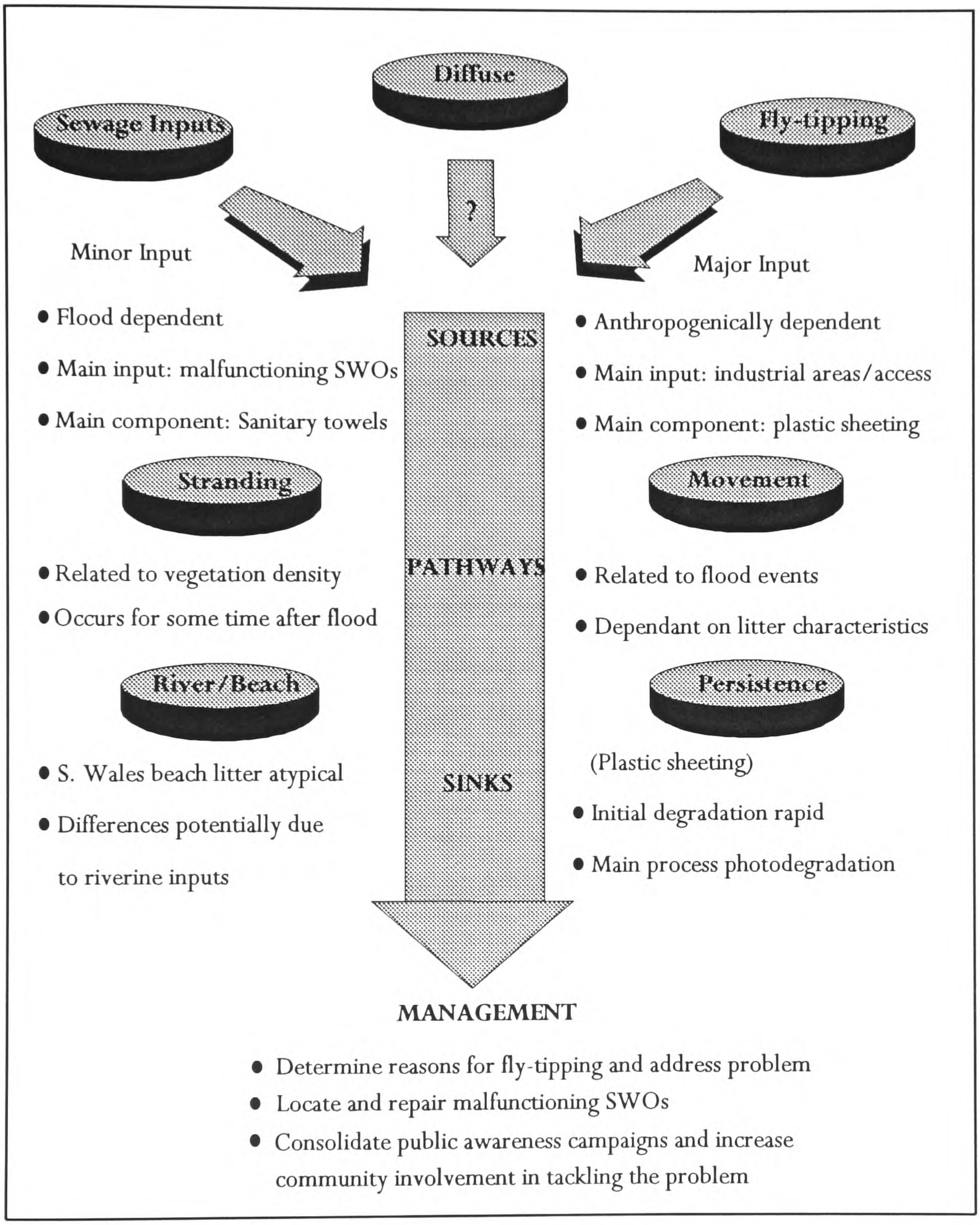
The ultimate sink for the variety of litter items found within the catchment is difficult to ascertain. Fly-tipping inputs were considered to have three main fates; ***scavenging***, if items were deemed to have further potential use, e.g. furniture; ***burial***, if litter was capable of aggregating soil particles, e.g. cloth; or ***transportation to river flow***, if litter was suitably light and mobile, e.g. plastic sheeting. Contrastingly, almost all items from SWOs initially entered the river flow, even if stranding occurred immediately. Eventual fates of litter transported in the watercourse could be numerous. Burial and fragmentation are two likely options, largely dependent on the litter fabrication material. As plastic sheeting constituted a large part of the litter problem, a study was carried out to monitor the degradation of such material within riverine conditions. Despite problems encountered in simulating environmental exposure, degradation was observed over a four month period. Results indicated that initial plastic (LDPE) breakdown was rapid, especially during the first week of exposure. Subsequent breakdown was slow and, during the survey period, samples did not reach a stage where fragmentation was likely. Sample burial dramatically halted the degradation process, suggesting photodegradation as the principal cause of sample deterioration. It was not possible to predict lifetimes for plastics in rivers from the test results, as they could not be realistically subjected to abrasive actions that would have been encountered during transportation as the test samples were tethered during the study. Results did, however, indicate that breakdown was not immediate, especially if samples were buried, and that transportation to sea could not be ruled out as a possibility. In light of recent complaints and subsequent research regarding accumulations of plastic sheeting within the Bristol Channel (Williams et al, 1993b), the potential of rivers as contributors to these problems must be considered.

Baseline Study

Links between process studies and baseline assessments have been discussed above. Baseline results showed the Taff catchment to be atypical in the scale of its litter problem. Both the E. Lyn and Avill had bank litter, but not to a degree that constituted a real problem. The major litter components in the E. Lyn and Avill were still plastic, but contained very little, or no sewage-related items. Litter in these areas was likely to result from diffuse inputs.

Within the Taff catchment, however, two distinct problems were highlighted. Twenty three percent of all litter within the catchment was of sewage origin, the remainder a combination of fly-tipping and diffuse inputs. On the whole, diffuse inputs were considered to be minimal, perhaps with the exception of some urban centres. It is therefore likely that the principal input of litter in the Taff is from fly-tipping inputs. The baseline survey highlighted industrial areas as being most susceptible to illegal tipping. Any action taken to amend this problem should therefore be directed towards these areas first. A schematic model was developed to summarise the processes and interactions governing riverine litter sources, pathways and sinks (Fig. 9.1).

Figure 9.1. Schematic Model Showing Processes and Interactions Governing Riverine Litter



Management

The Keep Wales Tidy Campaign has already launched an initiative to tackle the Taff litter problem. The reactive clean-up approach that has been taken, however, will have questionable impact if carried out in isolation. The clearance study (Chapter 7) carried out in this research demonstrated that litter re-accumulation at cleared areas is inevitable and fairly rapid if inputs are not prevented. In order to ensure the success of this campaign, immediate measures need to be taken to tackle litter sources.

Results obtained in this study pinpointed fly-tipping and sewage inputs as major litter point-source contributors. Following Davies' (1989) work, measures were taken to begin addressing sewage problems by locating and carrying out appropriate maintenance on the worst outfalls. To date, however, little emphasis has be given to tackling the fly-tipping problem, the major litter problem within the Taff catchment. Before action can be taken, a better understanding needs to be gained of the problem. Tipping sites have emerged in many areas where vehicular access or over the boundary tipping is possible. In many cases, the tipped waste comprises of ordinary household waste or furniture which could, in many cases, have been removed free of charge by Local Authorities. Crucial facts that need to be determined are, whether adequate services exist, and if they do, whether the public are aware of them. This consultation process is vital in gaining feedback from the public regarding perceived inadequacies in the current disposal services. It is only then that reasons for this problem can be understood. Whatever the outcome, the public needs to be made aware of the problem, and measures taken to eradicate it. In parallel with a promotion of correct waste disposal routes, it would seem wise to enforce current legislation available to prosecute offenders. Although prosecutions are difficult to bring about, the effect of a few high profile prosecutions, enforcing large fines, could provide a suitable catalyst to change public attitudes. Again reactive measures, such as cleaning tipping sites and barricading access points have proven ineffective (Chapter 5). Such action is only really appropriate after efforts have been made to deal with the cause of the problem. An initiative to tackling fly-tipping is considered to be pivotal in any campaign addressing the Taff litter problem.

To achieve long-term improvements in litter control, the education and involvement of the public is paramount. The Tidy Britain Group's "People and Places" initiative already works closely with schools to increase childrens awareness of litter problems. It is possible that such action should be strengthened in litter problem areas such as the Taff catchment, and that efforts should also be made to enlighten adult members of the community. Discussions with the public held during fieldwork, highlighted that the Taff was commonly regarded as a river of poor quality. Positive promotion regarding recent improvements in water quality could only improve current public opinion, and could also be used to emphasise litter as a serious pollutant, and one which everyone has some control over. Whilst negative attitudes remain regarding the state of the Taff, the public are also likely to continue to abuse this resource and regard it as the waste disposal system it once was.

Often environmental management policies, although well meant, become ineffective due to their fragmented nature. This could well be the case if rivers are considered to be significant litter contributions to marine areas. Too frequently coastal management is blinkered in its approach, concentrating on individual areas when developing strategies rather than regarding the whole picture. Halliday and Smith's (1992, p165) comment that "Nearshore waters are frequently administered and managed as distinct from their neighbouring maritime and coastal environments, and the third component of the trilogy, the coastal land, forms a further exclusive managerial dimension" is particularly apt. Problems such as marine litter which result from a variety of source inputs are prime examples of those that would benefit the most from a broader management approach.

The Code of Practice on Litter and Refuse (HMSO, 1990) constitutes the most recent, extensive piece of legislation addressing the litter problem. It outlines cleanliness standards which should be met for different location types, and gives reasonable time-scales in which clearance work should be achieved. Under this legislation, standards are set for towns, parks, roads, railway embankments, canal tow-paths, and even beaches, but no mention is given to rivers. It is imperative to the success of any future management policy that this legislative gap is filled. In order to do so, not only will effective assessment methods have to be developed, but also responsibility, or "duties", will need to be apportioned to suitable bodies to ensure standards are met. Within the current framework of bodies concerned with riverine litter, this would seem to be most easily implemented through split responsibility between the NRA and Local Authorities. Due to the NRA's current role in policing and monitoring rivers, a logical extension of this would be for their remit to include the control of point-source inputs, and general river litter monitoring. Similarly, the Local Authoritie's responsibility could also be extended to encompass rivers, but in a more reactive manner to undertake necessary clean-up activities. Only when clearer delineation of responsibility for riverine litter is achieved can procedures be formulated to tackle the problem effectively.

Future Work

Due to the extremely original nature of this research, the potential for future work is vast. Litter has become regarded as a pollutant due to the visual environmental degradation it causes. Impacts cannot be measured as traditional biological and chemical parameters, but are largely dependent on individual perceptions. To provide a framework for litter management, standards need to be assessed and, in order to do this, public perception of the riverine litter problem needs to be better understood. In general public perception of litter is a whole new area which is only just starting to be explored, and as such constitutes an essential basis for future work.

Regarding inputs, more work is needed to provide a realistic approach to measuring impacts of SWOs. Current methods of visual assessment and sample collection are limited and could be refined in future work. To tackle fly-tipping, assessments of current disposal practices and public consultations regarding awareness of facilities are both necessary to formulate suitable action plans.

Future work could also be carried out in the area of litter movement patterns. There is scope for large-scale clearance and tracer studies to gain a better understanding of movement through the catchment. Tracers could also be used to gain more information on river/beach interface activities. In short, all the studies carried out to investigate river litter processes could be continued in future research.

The baseline study also has potential to be developed further, perhaps to provide a rating system for litter pollution on rivers, similar to the classification for other pollutants. This would require application of the survey to many more river systems, and would need to link in with perception research to eventually produce a rating system. In this way, the baseline study could be used to set standards on a national basis once it has been adapted into a more user-friendly format.

In summary, this research has taken a first step towards developing methods to understand and monitor river litter problems. Ideas have evolved from research in many related fields and have been adapted and applied using scientifically rigorous techniques. The broad-base approach taken in this work was adopted so that initial headway could be made into a complex and multifaceted problem. It is hoped that any future work will help to refine and broaden knowledge in this research area.

CHAPTER 10

CONCLUSIONS

The baseline survey developed for this research proved a very effective means of assessing litter within river catchments. Statistical analyses carried out on the data collected produced meaningful results when sufficient data were available. Results from the Taff catchment were atypical in the scale of litter problem exhibited. This was considered primarily to be due to intense linear urbanisation characteristic of the S. Wales valleys, and partially the high rainfall levels (Chapter 2), exerting stress on the combined sewer system, and public attitudes towards acceptable waste disposal routes. In comparison, the E. Lyn and Avill were far less polluted. Both catchments are predominantly rural, and are popular tourist destinations. No increases in litter were, however, recorded during the tourist season.

The main litter component in all catchments was plastic material, more specifically plastic sheeting. This was followed by sewage-derived items in the Taff, in particular, feminine hygiene products. Within the E. Lyn and Avill, sewage litter was not a problem. In fact, no major litter point-sources could be located in the E. Lyn and Avill, suggesting inputs were mainly diffuse. Contrastingly, the Taff was shown to have two major input sources; fly-tipping and sewage inputs.

Fly-tipping is a widespread problem in the Taff catchment, and was shown to be most prevalent in industrial areas and those that offered road access close to the river. Tipped waste comprised predominantly of household type material, the major individual component being plastic sheeting. Sporadic inputs of DIY-related waste was also recorded, but during the survey, no obvious commercial dumping was noted.

Three fates were determined for this dumped litter; loss by scavenging, burial, or transportation to the river flow. Particular fates for litter items appeared to be determined due to physical characteristics or potential for further use. Site clearances and access barricades were shown to be ineffective as preventative measures. Immediate action was considered appropriate to address the problem's root cause; the reason why waste is illegally tipped.

Sewage inputs were considerable, but varied between SWOs. Impacts ranged from gross litter inputs at malfunctioning SWOs, to no inputs from non-operational SWOs or merely discharges of surface drainage. Overall, significantly greater quantities of sewage litter were found at sites where sewage pipes were in close proximity. This suggests that either frequent gross inputs ensure sewage 'hot spots' remain, or sewage litter generally lacks the mobility to bring about immediate dispersal. Current assessment techniques are inadequate to measure moderately polluting SWOs, due to the difficulty in distinguishing point source inputs from general background levels. A need was also pinpointed to standardise SWO documentation between water companies, Local Authorities and the NRA. These parties are involved in controlling discharges, maintaining pipe work, and monitoring effluent respectively, and disparity between records makes any SWO assessments problematical. Inputs comprised of large volumes of toilet paper, faecal matter, cotton material and food, but sanitary towels constituted the most numerous single litter item.

Principal litter components were plastic sheeting and sanitary towels/panty liners. These were therefore selected for more detailed analyses regarding their potential fate. Degradation of panty liner backing strips indicated that significant initial breakdown occurred, but that subsequent degradation was slow. Photodegradation was highlighted as the main cause of breakdown, due to the lack of degradation monitored in buried samples. Simulation of the physical abrasion of samples mobile in the river flow was not possible due to the sample's static position necessary for analysis, but under the remaining realistic environmental conditions, little breakdown occurred in the four month measurement period.

In-flow measurements and riverbank clearance studies provided insight regarding litter transportation. Litter movement was linked with flood events, the litter quantities deposited appearing to reflect flood magnitudes. Deposition occurred for some time after the flood event, and was most intense in the mid-bank zone. Litter stranding was also shown to be significantly related to vegetation density, i.e. certain litter types were found in greater numbers at sites where vegetation was most dense. Plastic sheeting was found to be highly mobile during flood events, even though it was susceptible to stranding once the water levels receded. Riverine litter transportation to sea was considered possible from the movement patterns studied. Beach litter surveys also reflected this possibility, as litter profiles for S. Wales' beaches were found to be disparate from those representing UK/Irish Sea beaches.

This research constitutes one of the ***first*** attempts at defining methods to assess and understand the process involved in river litter problems. It is hoped that this work will provide the impetus to promote future work in this very necessary research area.

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Appendix A

A1: Coastwatch UK Survey Form

- Please read the questionnaire before attempting this survey and work a survey plan around low tide

Enter details of question A1 and return form by FRIDAY 12 OCTOBER

National Co-ordinator

KATHY POND, FARNBOROUGH COLLEGE OF TECHNOLOGY,
BOUNDARY ROAD, FARNBOROUGH, HANTS. GU14 6SB

Telephone

0252 — 377503

A INFORMATION ON SITE/SURVEY

A1 Country Code [ ] County Code [ ] Block Code [ ] Unit Code [ ]

A11 Northings Co-ordinates [ ] Eastings Co-ordinates [ ]

A2 Name of survey unit or area [ ]

A3 Your name and address if you wish to be contacted

Name [ ]

Address [ ]

Telephone [ ]

A4 Date of Survey

Day [ ] Month [ ] Year [ ]

A5 Do you know your site:

Well [ ] A little [ ] Here on 1st or 2nd visit [ ]

A6 Is your coastal unit a specially designated area or part of one?*

Yes [ ] No [ ] Dont Know [ ]

A7 If Yes please specify is it (E C means European Community)

An E C Bathing Water [1] An E C Shell Fish Area [2] An E C Bird Directive Area [3] Area of Scientific Importance [4] Nature Reserve [5] Other [6]

A8 Is access to your coastal unit *

Easy [1] Difficult [2] Normally Impossible [3] Prohibited [4]

B INFLUENCES FROM LAND — Influences from the areas up to 500m beyond the splash zone

B1 Is the immediate adjoining land (up to 500m from shore) mainly devoted to (tick one or two options only)

Intensive Grazing	[1]	Tillage, farming incl horticulture	[2]	Scrub or rough grazing	[3]	Dune	[4]
Park/wood/forest	[5]	Bog/marsh	[6]	Rock Glacier/Sand	[7]	Village or town residential	[8]
Tourist Resort	[9]	Waste Tip	[10]	Industry	[11]	Transport Port	[12]
Construction Site	[13]	Other	[14]				

B2 Note all inflows as you walk your unit, and indicate type and character of each
You may abbreviate River (R), Storm drain (SD), Pipe (P), Open drain (OD), Seepage (S). Carry out a nitrate test on one inflow per unit

Type of inflow	Does its content or area below mouth have: Carries water at time of survey YES/NO	Oil smell	Discolouration	Dead Fish	Dumped debris	Sewage Fungus	Scum froth	Oil Petrol	Nitrate † (mg/l NO_3)	Shore level P SD or OD is ending at: High	Mid	Low	Sub*
1													
2													
3													
4													
5													
TOTAL 1	2	3	4	5	6	7	8	9	10	11			

*Sublit is below low tide mark

† Enter 0, 10, 25, 50, 100, 250 or 500 depending upon the colour change of the nitrate stick

E3 Note which of the following items of general litter or pollution you found on your unit and indicate whether they occur in the upper shore or intertidal zones:

	Splash Zone	Tide mark/ Intertidal sea
Plastic Fishing Gear (nets, lines, bags)	1	2
Packing strap(s) and beer can holder(s)	3	4
Other plastics (bottles etc. but not sanitary plastic)	5	6
Polystyrene	7	8
Tar	9	10
Oil, petrol/diesel	11	12
Container(s) of potentially hazardous substances (chemicals, gas cylinders)	13	14
Textiles, shoes, gloves, items of clothing	15	16
Paper, cardboard, wood	17	18
Food, fish waste and bones	19	20
Faeces (Mammal)	21	22
Sanitary materials (e.g. sanitary towel backings, condoms)	23	24
Medical Waste e.g. syringes	25	26
Glass	27	28
Cans	29	30

E4 If you know the unit well please estimate frequency of sewage pollution incidents: (otherwise leave blank)

Never ☐ Rare ☐ Occasional ☐ Frequent ☐ Usual ☐ Seasonal ☐

F GENERAL OBSERVATIONS

F1 Has recent weather made the appearance of your coastal unit change?

Yes Looks cleaner than usual [1] Yes Looks worse than usual [2] No Recent weather is insignificant [3] Don't Know [4]

F2 Has the beach been cleaned within the last week?

Yes ☐ No ☐ Don't Know ☐

F3 Do you know of, or see, any serious threat to this block or unit?

Yes ☐ No ☐

F4 If you have any evidence of a serious threat, please indicate with a tick if it is from any of the options below. Please subtitle the tick with 'r' if you consider it is a significant risk or subtitle with 'i' if you consider it to be an imminent threat.

Erosion [1] Beach Mining [2] Construction [3] Dumping/ Tipping [4] Water Pollution Sewage [5]

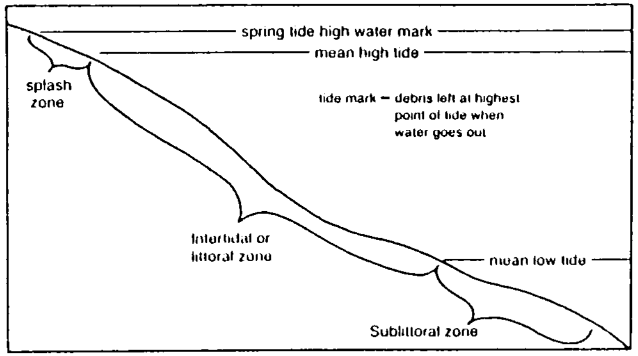
Water Pollution Radioactivity [6] Water Pollution Oil [7] Water Pollution Industry [8] Water Pollution Agriculture [9] Recreational Abuse [10]

Other [11] Aquaculture [12]

F5 Would you be interested in follow up work? If not leave blank, if yes, is it to:

Find out more about the unit [1] Investigate protective action [2] Instigate remedial action [3] Other [4]

F6 Please enter any short comment or observation (in block lettering)



C SPLASHZONE – The shoreline from mean high tide up to spring tide high watermark*

C1 Indicate the approximate width of splash zone (estimate dominant width in a non-uniform area)

0m [1] 0-5m [2] 5-50m [3] 50-250m [4] 250m+ [5]

C2 Indicate the dominant coverage of the splash zone:

Saltmarsh [1] Reed Bed [2] Other vegetation [3] Bare Rock/ Sand [4] Building or Construction [5]

D INTERTIDAL AREA – The area between high and low tides. It is reduced to the waters edge in non-tidal areas.

D1 Estimate the average width of the intertidal area. If width varies greatly, tick two boxes.

less than 5m [ ] 5-50m [ ] 50-250m [ ] 250m+ [ ]

D2 Ticking a maximum of 2 categories, indicate what the intertidal surface is mainly composed of

Solid Rock [1] Boulders ø20cm+ [2] Gravel ø0·2-20cm [3] Sand [4] Silt or Mud [5] Other (built walls) [6]

D3 Which of the plants listed did you find growing in your unit?*

*Spartina Grass [1] *Eel Grass [2] Brown, Red or Green Seaweed [3]

Green Algae on Mudflats: Patches (up to 3m diameter) [4] Extensive Cover or thick mats [5]

*Note Spartina grass is a hard long grass which remains standing up when the tide is out, growing on mud/sand flat areas. Eel grass lies down when the tide goes out and has flat long narrow leaves (not tubes characteristic of similar algae)

D4 Is there any area in your unit with extensive foams, scum or film on shore or water?

Yes [ ] No [ ]

D5 Indicate which of the animals listed you found live (L) or dead (D)

Jellyfish [ ] Worms and Wormcasts [ ] Shellfish e g cockles, winkles [L D] Crustaceans e g crab [L D] Fish [L D]

Seabirds [L D] Seal [L D] Dolphin [L D] Rat [L D] Other [ ]

D6 Did you find any oiled birds during your survey?

Yes [ ] No [ ] If yes, indicate no of birds [ ]

E LITTER AND POLLUTION at all shore levels

E1 Describe the general state of littering of the splash zone, the intertidal area and the tide mark(s) giving approximate *percentage cover in a given litter category, choosing between none (0), 0-25%, 25-50%, 50-75% or 75-100%. Each vertical column should add up to 100%

	Splash zone	Inter tidal	Tide Mark
Gross More-or-less continuous, impossible to avoid when walking on the shore	1	2	3
Moderate Noticeable litter	4	5	6
Slight or none No litter observed, or less than 10 items	7	8	9

*Enter the upper value of the range, i e None is entered as 0, up to 25% enter 25%, 20-50% enter 50% etc

E2 Note any major items found on your unit and indicate whether they occur on the upper shore or intertidal/sea zones

MATERIAL	Splash Zone	Tide Mark Intertidal Sea
Landfill materials (e g concrete, rubble, debris from sea defence etc)	1	2
Large metal object (e g abandoned vehicles, machinery, girders (exclude bins))	3	4
Household furnishings (e g beds, carpets, pieces of furniture etc)	5	6
Household refuse in bags or piles of rubbish	7	8
Ship Wreckage, incl small metal parts	9	10
Other	11	12

NORWICH UNION COASTWATCH UK

G1 Chemical inflows - pH, phosphate and nitrate.
Please enter the pH, phosphate and nitrate values of inflows into your block, characterising the type of inflow as river (R), storm drain (SD), pipe (P), open drain (OD), seepage (S), as in question B2 on the 'Norwich Union Coastwatch UK' questionnaire. Could you also ensure that you enter nitrate readings into both B2 and this section.

	1	2	3	4	5	6	7	8	9	10
Type of inflow										
pH										
Phosphate (ppm)										
Nitrate (ppm)										

G2 Chemical seawater - pH and phosphate.
Please enter the pH and phosphate values for any seawater samples in this section.

	1	2	3	4	5	6	7	8	9	10
pH										
Phosphate (ppm)										

G3 Microbiological Tests - Faecal streptococci in seawater.
Please enter the number of black/brown coloured bottles in each sample set of five bottles. By referring to the instruction sheet, please indicate the most probable number (MPN) of bacteria per 100 mls of seawater sample. Also could you give a brief description of the location of the sample point.

	Location	Black/Brown bottles (max 5)	MPN Bacteria per 100mls seawater
Sample 1			
Sample 2			

A2: Garber Survey Logsheet

GARBER SURVEY LOGSHEET - KEY

SECTION A

COLOUR - NORMAL		0
ABNORMAL CHANGE		1
MINERAL OIL - NO FILM OR ODOUR		0
FILM AND/OR ODOUR PRESENT		1
SAS NO LASTING FOAM VISIBLE		0
LASTING FOAM VISIBLE		1
PHENOLS - NO SPECIFIC ODOUR		0
ODOUR PRESENT		1
TAR/FLOATING MATTER	ABSENT	0
(WOOD, PLASTIC, GLASS, ETC.)	PRESENT	1

SECTION B

Position on Beach

1 = STRANDLINE
2 = BETWEEN 1 & 3
3 = WATERS EDGE

Material Quantification

0 = ABSENCE OF CODED MATERIAL
1 = TRACE OF CODED MATERIAL
2 = SOME MATERIAL AT INTERVALS
3 = SUFFICIENT TO BE OBJECTIONABLE

WEATHER CODE

Wind Force

0 CALM
1 LIGHT AIRS
2 LIGHT BREEZE
3 GENTLE BREEZE
4 MODERATE BREEZE
5 FRESH BREEZE
6 STRONG BREEZE

Wind Direction

USE FIRST TWO FIGURE OF COMPASS BEARING EG.

NORTHERLY = 00 (0°)
EASTERLY = 09 (90°)
SOUTHERLY = 18 (180°)
WESTERLY = 27 (270°)

Sea State

0 CALM, GLASSY
1 CALM, RIPPLED
2 WAVES ½ - 1ft
3 WAVES 1 - 2ft
4 WAVES 2 - 4ft
5 WAVES 4 - 8ft
6 WAVES 8ft

Sun State

0 SUN OBSCURED
1 WEAK SUN, NO SHADOW
2 WEAK SUN, SHADOWS
3 SUN OCCASIONALLY OBSCURED BY PASSING CLOUDS
4 BRIGHT SUNSHINE

ENTER AS:

WIND FORCE	WIND DIR	SEA ST.	SUN ST.

GARBER SURVEY LOGSHEET

DATE:

SAMPLER:

RUN: I.D.:

					SECTION A						SECTION B											
					RELATIVE TIME OF TIDE	COLOUR	MINERAL OIL	SURFACE ACTIVE SUBSTANCES	PHENOL	TAR/FLOATING MATERIALS	POSITION IN BEACH	INTACT FAECES	GREASE/SCUM	SEWAGE DEBRIS	CONTRACEPTIVES TAMPON APPLICATORS	SANITARY TOWELS	NOXIOUS SEWAGE ODOURS	NO. BATHERS	NO. BEACH USERS	ARG's	PURPOSE	LAB REF NO.
BEACH	SPN	WEATHER	TIME	H.W.	9247	9467	9242	9243	9244	9245												
											1											
SAMPLERS COMMENTS:											2											
											3											
											1											
SAMPLERS COMMENTS:											2											
											3											
											1											
SAMPLERS COMMENTS:											2											
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SAMPLERS COMMENTS:											2											
											3											
											1											
SAMPLERS COMMENTS:											2											
											3											

A3: NRA Bankside Litter Survey Form

NATIONAL RIVERS AUTHORITY (WELSH REGION)
South East Area Environmental Appraisal Unit

Bankside Litter Survey Form

River: River Reach: u/s NGR

d/s NGR

Reach Code:

Date: Recorder(s):

Sketch of Survey Area:
(Select a survey area to a maximum length of 40m i.e. 20m u/s and d/s of your access point. If possible survey the whole length and width of the survey are but if it is not possible to access both banks then define clearly the area surveyed on the plan)

Physical Characteristics of Reach:

1.Riffle/fast run/slow run/glide/pool,etc.?

2.Description of bank - walled / steeply sloping /gently sloping/ overhanging, etc.,?

3.Vegetation types (tick if present)

Trees ☐ Tree Roots ☐ Shrubs/Bushe ☐ Low plants ☐ Grasses ☐

estimate %age of reach with overhanging vegetation:

Record maximum height of litter (m) in branches and state wheter or not this is still within the flood channel if possible:

Describe any point sources of litter from e.g. STW storm water, Storm Sewage Overflows (S.S.O's). Complete the quantiative and qualitative litter descriptions - 1 for u/s and 1 for d/s source. Include the name of the outfall:

Was the discharge occuring under Dry Weather Flow conditions?

Record any tributaries and state wheter or not the input appears to be a major source of litter. If necessary complete an /s and d/s assessment as above.

Select a 5M wide transect of the bank and semi-quantitatively assess the bankside litter from the river channel upwards. Divide the bank subjectively into lower, middle and upper bank and record in Table 1 overleaf:

TABLE 1 QUALITATIVE DESCRIPTION OF LITTER IN SURVEY AREA

REACH CODE:

MAJOR CATEGORIES	DESCRIPTION	RIVER CHANNEL	BANKSIDE LEFT	BANKSIDE RIGHT	TOTAL REACH SCORE
SEWAGE	toilet paper				
	contraceptives				
	sanitary towels				
	napkin liners				
	cotton buds				
	sewage smell				
	other (specify)				
REFUSE	angling litter				
	road cones				
	polystyrene				
	plastic crates				
	plastic strips				
	<30cm length				
	30-50cm length				
	>50 cm length				
	clothing				
	cans				
	metal objects				
	bottles				
	vehicles (or parts of vehicles)				
	tyres/wheels				
	supermarket trolleys				
	furniture				
	plastic/metal drums				
	builders rubble				
	other (specify)				
OTHER	(specify)				

TICK IF LITTER PREDOMINATELY CAUGHT ON BANKSIDE VEGETATION

0=Absence of material
1=Traces of material
2=Some material at intervals
3=Gross contamination

TABLE 2 SEMI-QUANTITATIVE ASSESSMENT OF LITTER IN 5m TRANSECT

REACH CODE: LEFT OR RIGHT BANK

MAJOR CATEGORIES	DESCRIPTION	LOWER BANK	MID BANK	UPPER BANK
SEWAGE	toilet paper			
	contraceptives			
	sanitary towels			
	napkin liners			
	cotton buds			
	sewage smell			
	other (specify)			
REFUSE	angling litter			
	road cones			
	polystyrene			
	plastic crates			
	plastic strips			
	<10cm length			
	10-50cm length			
	>50 cm length			
	clothing			
	cans			
	metal objects			
	bottles			
	vehicles (or parts			
	of vehicles)			
	tyres/wheels			
	supermarket-			
	trollies			
	furniture			
	plastic/metal			
	drums			
	builders rubble			
	other (specify)			
OTHER	(specify)			
TICK IF LITTER PREDOMINANTLY CAUGHT ON BANKSIDE VEGETATION				

0=0
1-10=1
11-100=2
101-1000=3
>1000=4
NUMBER OF ITEMS OF LITTER

A4: Marine Litter Research Programme Survey Form

KEEP BRITAIN TIDY GROUP : MARINE LITTER RESEARCH PROGRAMME

UNITED KINGDOM : BASELINE STUDY

AREA

TIME

OBSERVERS

DATE

LOCATION

TRANSECT No:

BEACH TYPE

CONTAINERS

1 TYPE OF CONTAINER, MATERIAL, COLOUR	2 ORIGINAL CONTENTS	3 COUNTRY OF ORIGIN	4 MARKINGS

OTHER

PAPER		
CARDBOARD		
PLASTIC FRAGMENTS		
PLASTIC BAGS OR SHEETING		
GLASS		
METAL		
WOOD		
OIL		
SHOTGUN CARTRIDGES	PLASTIC CASE	
	PAPER CASE	

LITTER

RAW SEWAGE	
FISHING NET	
FISHING LINE	
ROPE	
WIRE	
CLOTHING	
PAPER OR PLASTIC CUPS	
CONFECTIONARY WRAPPINGS	
OTHER FINDS	

COMPOSITION OF LITTER BY WEIGHT

PLASTICS	METAL	GLASS	WOOD	OTHERS

HEAVY ITEMS >15 KG

A5: The Yorkshire Rivers Litter Monitoring Project Survey Form

ORGANISATION ON THE DAY.

i) RALLY VOLUNTEERS.

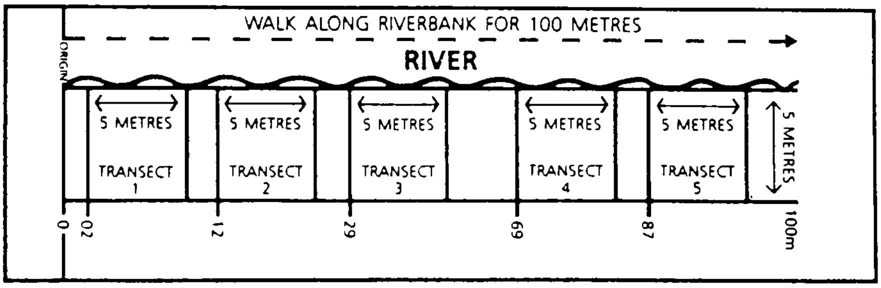
Designate one point where your group will meet, well away from the water's edge. Fix a central spot for equipment.

ii) ESTABLISH A STUDY AREA.

PERMISSION: Ensure you have obtained authority from all the relevant organisations.
FIX A SITE: Pick a stretch of river bank where litter is clearly visible and accessible (free from obstruction e.g. shrubs). Some areas may only have minimal amounts of litter whereas it may accumulate at places where the water slows. Once the site is fixed, don't change it. You will only survey certain stretches of the area (transects).
MARK OUT YOUR SITE: Measure out a stretch of bank 100m x 5m. Use fence posts, trees and other permanent features to fix the position of the site.
MAP: Make a sketch map and take a photograph of your site. Indicate specific black spots.

iii) TRANSECT SURVEY METHODOLOGY.

In order for the survey to be statistically correct, you must ensure that the transects you monitor within your chosen site are chosen randomly.
ESTABLISHING TRANSECT LINES: These are established by using a random number table. Select 5 random numbers, below the value of 95. Remember to ignore values which are not applicable i.e. they result in transects overlapping.
EXAMPLE: ESTABLISHING TRANSECT LINES.
The numbers 29, 12, 87, 02, 69 were chosen from the random number tables.
Walk along the river bank. Mark out transect areas 5 metres long, and 5 metres wide, after 2m, 12m, 29m, 69m and 87m.



iv) CLEAR UP AFTERWARDS.

In order to benefit the environment, clear up all the litter on the 100m stretch, once the monitoring is complete. Your local authority may be able to provide plastic bags and a skip.

v) CONTINUING THE MONITORING.

The degree of pollution will vary, depending on the water flow, seasons, use of the river by different people and other factors. So, regular monitoring will be necessary.
Decide on a suitable time interval between monitoring visits. We suggest one visit every month. For each subsequent survey, repeat the monitoring for different, randomly chosen transects and enter the details on new forms, identifying clearly the visit number.

RECORDING YOUR FINDINGS

FILLING IN THE FORMS

There are 3 forms to complete. Fill in FORM A first. Then observe the types of litter on the site and record them on FORM B. Finally, you can study some of the items on FORM B in more detail- record this analysis on FORM C.
Please feel free to add more sheets if you need to.
The forms are intended to be photocopied; you keep the original.

PHOTOGRAPHS

It will be useful to take a camera and to photograph the exact location of your site. The photos will also build up a good record of your project as it develops. You can photograph the litter collected at each visit for future reference. Don't forget to include a map too.

RETURN YOUR COMPLETED FORMS TO...

-The Tidy Britain Group (the address is on the back page).

ANALYSING YOUR FINDINGS

* FORM A *

Please make sure you fill in all sections of this form in as much detail as possible. Pay particular attention to the description of the site and your observations about possible sources of pollution.

* FORM B *

Fill in the quantities of each type of litter on FORM B and then add up the totals.
Please record all the items which you find on the river **bank**, WITHIN THE CHOSEN TRANSECT LINES. Ignore the waste which has collected outside the transects or that which you see in the river. There is no need to separate the litter collected from each transect.

* FORM C *

Then complete FORM C. Below you will find ways of identifying the items in more detail.

LITTER TYPE

We are particularly concerned about any CONTAINERS which you find, such as bottles, drums, tins, cans, boxes, canisters and crates. If something is made of more than one material, decide which is most important. Look at the labelling and record the contents and manufacturer's trade name.

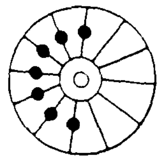
OTHER COMMENTS/ORIGIN

Look for lettering or other marks stamped on the litter. Often they are found on the base e.g. manufacturer's address or other wording. Highlight possible sources such as a nearby pub, picnic area, factory or business.

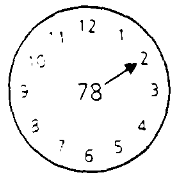
HOW OLD IS THE LITTER?

DATE CODES: Materials are dated in several different ways.
i) Sell by dates: the most frequently found. Will give an indication of the age of the litter.

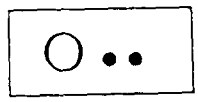
ii) Clock code Type A: The year a bottle was made is shown by the number in the centre of the circle. 0= 1980, 1=1981 etc. The month of bottle production is shown by the number of dots on the radiating lines. **Here**, there are 7 dots, so the month of production = the 7th month = July. The container was produced in July 1980.



iii) Clock code Type B: The last 2 digits of the year of production are found in the centre. An arrow points to a single number on the outside of the circle, representing the month. **Here**, the container was made in February 1978



iv) Dots and A Number: The number at the end or the beginning of the row = the last digit of the year of production. e.g.7=1987. Dots show the month in the year when the container was made. One dot is removed for each month, so 12 dots is January, 9 dots is April etc.
Here, the date of production would be November 1980.



WHERE WAS IT MADE?

BAR CODES
There will probably be very little foreign waste in the rivers, although you will find more if the river is estuarine. Bar codes consist of a series of numbers and parallel vertical lines; each product sold in a supermarket will have its own code.

First 2 numbers= nationality of the 'number bank'.
Next 5 numbers= manufacturer
Last 5 numbers= product.

5 000166 302524

00-09 USA Canada
30-37 France
40-43 West Germany
49 Japan
50 UK
54 Belgium
57 Denmark
64 Finland

70 Norway
73 Sweden
76 Switzerland
77 Australia
80-83 Italy
84 Spain
89 Netherlands
90-91 Austria

Example:
50 00317 00201 3 = UK. Paperboard carton. Longlife milk. 1 Pint.

FORM A: DETAILS OF VISIT

Name of monitoring group

Contact Address

Tel No.

Postcode

Location of monitoring site.

Ordnance Survey map reference number

Address/name of site

Names of nearest town and county

Description of site. (e.g. Recreational, industrial use)

Possible sources of Litter. (e.g. A.N.Other's scrap yard 100 metres upstream)

Any other observations. (e.g. Pollution in the river, historical info., weather conditions, wildlife)

Date and Number of this visit. (i.e. First visit = no. 1)

Date of your last visit

FORM B: TYPE AND NUMBER OF ALL LITTER OBSERVED

Tick each time you find an item. If frequent, write "Widespread"

TYPE OF LITTER		NUMBER OF ITEMS	TOTALS
A. PAPER	Tickets,stickers		
	Tissues		
	Paper bags		
	Newspaper		
	Receipts		
	Other paper		
B. CARDBOARD	Matchboxes		
	Drink cartons		
	Cigarette packs		
	Boxes		
	Other cardboard		
C. PLASTICS	Bags		
	Cellophane wrapping		
	Crisp packets		
	Pots		
	Bottles		
	Polystyrene (foam)		
	Sheeting		
	Other plastic		
D. GLASS	Soft drink bottles		
	Booze bottles		
	Other glass		
E. METALS	Fasteners		
	Drinks Cans		
	Food cans		
	Foil		
	Batteries		
	Other metals		
F. WOOD.	Lolly sticks		
	Other wood		
G. FAST FOOD.	Boxes, wrappings		
	Cups		
	Cutlery		
	Other fast food		
H SMALL ITEMS.	Cigarette ends		
	Sweet wrappers		
	Bottle tops		
	Paper		
	Ring pulls		
	Match sticks		
I FISHING EQUIPMENT	Fishing net		
	Fishing line		
	Other		
J. OIL	Oil spillage		
	Oil cans		
K. ROPE			
L. WIRE			
M OTHER LITTER	Food remains		
	Shotgun cartridges		
	Clothing		
	Sewage items		
	Any other litter		

FORM C: DETAILS OF LITTER FOUND ON RIVER BANK

Please use the information in the section "Analysing Your Findings" to complete this form.

1.LITTER TYPE	2.WHEN WAS IT MADE?	3.WHERE WAS IT MADE?	4.COMMENTS/ ORIGIN
Example: White Plastic Bottle	1938	France	T '+, CASCELLOID 417 Public House 75 yards Upstream

A6: Riverine Litter Pilot Survey Form

Monitoring Group/Person: ______________________________

Contact Address: ______________________________

____

____

____

Tel. No.: ________________ Fax No.: ________________

****

<u>Site Information</u>

Survey Date: _____/_____/_____

River Name: ________________

Site Name: ________________

Nearest Town: ________________

County: ________________

Eastings Co-ordinates: ____________ Northings Co-ordinates: ____________

<u>Reference Information</u>

Site Sketch:

Access Via:

Land Use & Road Networks

(Tick category which best describes area 300m radius upstream of site.)

Residential: _____

Industrial: _____

Commercial: _____

Open Space: _____

Res/Ind: _____

Res/Comm: _____

Ind/Comm: _____

Res/Open: _____

Ind/Open: _____

Comm/Open: _____

Road Network:

Dense: _____

Medium: _____

Sparse: _____

Road/Track proximity to river bank (<50m): _____

Bank Type

Natural _____ Man-modified _____ Combination _____

Bank Profile

Left Bank: 0-15: __ 15-30: __ 30-45: __ 45-60: __ >60: __

Right Bank: 0-15: __ 15-30: __ 30-45: __ 45-60: __ >60: __

River Width

<1m: ___ 1-2m: ___ 2-4m: ___ 4-8m: ___ >8m: ___

River Depth (Maximum at survey time)

<0.5m: ___ 0.5-1m: ___ 1-2m: ___ 2-4m: ___ >4m: ___

River Pattern

Torrent: _____

Pool/Riffle: _____

Without Riffle: _____

Meander: _____

Braided: _____

Physiognomic Vegetation Description

Average size	Trees	Shrubs	Herbs
Low:	<10m _____	<0.5m _____	<0.5m _____
Medium:	10-25m _____	0.5-2m _____	0.5-2m _____
Tall:	>25m _____	>2m _____	>2m _____

Density			
Sparse:	_____	_____	_____
Average:	_____	_____	_____
Dense:	_____	_____	_____

Veg/River Contact			
Minor:	_____	_____	_____
Average:	_____	_____	_____
Major:	_____	_____	_____

Immediate Point Source Inputs (50m upstream)

Storm Water Overflow/
Other Sewage Inputs: _____

Fly-tipping: _____

Other: _____ (Specify:_________________)

Qualitative Litter checklist - Transect 1

Family	Genus	Species	Presence/ Absence	Position A	B	C
Sewage-Derived	Feminine Hygiene	Sanitary Towel				
		Panty Liner				
		Tampon/App.				
	General	Toilet Paper				
		Napkin Liner				
		Contraceptive				
		Cotton Bud				
		Other/Unident.				
Housing Material	Combustible	Fencing				
		Hardboard/Wood				
		Other/Unident.				
	Non-combustible	Brick/Rubble				
		Floor Cover				
		Other/Unident.				
Household (Large)	Brown Goods	Furniture				
		Mattress/Foam				
		Other/Unident.				
	White Goods	Fridge/Freezer				
		Ceramic Sanitary				
		Other/Unident.				
Household (Small) Commercial/ Industrial	Metal	Cans/Tins				
		Aerosols				
		Container Drums				
		Sheeting				
		Other/Unident.				

Qualitative Litter checklist - Transect 1 Cont'd.

Family	Genus	Species	Presence/ Absence	Position A	B	C
	Plastic	Polystyrene				
		Sheeting < 30 cm				
		Sheeting 30-60 cm				
		Sheeting >60 cm				
		Plastic Bag				
		Sweet Paper				
		Bottle				
		Other/Unident.				
	Glass	Bottle				
		Other/Unident.				
Transport Associated	Motor Vehicles	Cars/Parts of				
		Motorbike				
		Other/Unident				
	General	Bicycle				
		Sign/Cone				
		Other/Unident.				
General	Packaging	Crate				
		Cardboard				
		Packaging Strap				
		Other/Unident.				
		Cloth/Shoe				
		Rope/Fishing line				
		Other/Unident.				

Qualitative Litter checklist - Transect 2

Family	Genus	Species	Presence/ Absence	Position A	B	C
Sewage-Derived	Feminine Hygiene	Sanitary Towel				
		Panty Liner				
		Tampon/App.				
	General	Toilet Paper				
		Napkin Liner				
		Contraceptive				
		Cotton Bud				
		Other/Unident.				
Housing Material	Combustible	Fencing				
		Hardboard/Wood				
		Other/Unident.				
	Non-combustible	Brick/Rubble				
		Floor Cover				
		Other/Unident.				
Household (Large)	Brown Goods	Furniture				
		Mattress/Foam				
		Other/Unident.				
	White Goods	Fridge/Freezer				
		Ceramic Sanitary				
		Other/Unident.				
Household (Small) Commercial/ Industrial	Metal	Cans/Tins				
		Aerosols				
		Container Drums				
		Sheeting				
		Other/Unident.				

Qualitative Litter checklist - Transect 2 Cont'd.

Family	Genus	Species	Presence/ Absence	Position A	B	C
	Plastic	Polystyrene				
		Sheeting < 30 cm				
		Sheeting 30-60 cm				
		Sheeting >60 cm				
		Plastic Bag				
		Sweet Paper				
		Bottle				
		Other/Unident.				
	Glass	Bottle				
		Other/Unident.				
Transport Associated	Motor Vehicles	Cars/Parts of				
		Motorbike				
		Other/Unident				
	General	Bicycle				
		Sign/Cone				
		Other/Unident.				
General	Packaging	Crate				
		Cardboard				
		Packaging Strap				
		Other/Unident.				
		Cloth/Shoe				
		Rope/Fishing line				
		Other/Unident.				

Qualitative Litter checklist - Transect 3

Family	Genus	Species	Presence/ Absence	Position A	B	C
Sewage-Derived	Feminine Hygiene	Sanitary Towel				
		Panty Liner				
		Tampon/App.				
	General	Toilet Paper				
		Napkin Liner				
		Contraceptive				
		Cotton Bud				
		Other/Unident.				
Housing Material	Combustible	Fencing				
		Hardboard/Wood				
		Other/Unident.				
	Non-combustible	Brick/Rubble				
		Floor Cover				
		Other/Unident.				
Household (Large)	Brown Goods	Furniture				
		Mattress/Foam				
		Other/Unident.				
	White Goods	Fridge/Freezer				
		Ceramic Sanitary				
		Other/Unident.				
Household (Small) Commercial/ Industrial	Metal	Cans/Tins				
		Aerosols				
		Container Drums				
		Sheeting				
		Other/Unident.				

Qualitative Litter checklist - Transect 3 Cont'd.

Family	Genus	Species	Presence/ Absence	Position A	B	C
	Plastic	Polystyrene				
		Sheeting < 30 cm				
		Sheeting 30-60 cm				
		Sheeting >60 cm				
		Plastic Bag				
		Sweet Paper				
		Bottle				
		Other/Unident.				
	Glass	Bottle				
		Other/Unident.				
Transport Associated	Motor Vehicles	Cars/Parts of				
		Motorbike				
		Other/Unident				
	General	Bicycle				
		Sign/Cone				
		Other/Unident.				
General	Packaging	Crate				
		Cardboard				
		Packaging Strap				
		Other/Unident.				
		Cloth/Shoe				
		Rope/Fishing line				
		Other/Unident.				

Quantitative Litter checklist - Left Bank.

Species	Number of Items in Quadrat with Height up Bank											
	1	2	3	4	5	6	7	8	9	10	11	12
Sanitary Towel												
Panty Liner												
Tampon/App.												
Toilet Paper												
Napkin Liner												
Contraceptive												
Cotton Bud												
Other/Unident.												
Fencing												
Hardboard/Wood												
Other/Unident.												
Brick/Rubble												
Floor Cover												
Other/Unident.												
Furniture												
Mattress/Foam												
Other/Unident.												
Fridge/Freezer												
Ceramic Sanitary												
Other/Unident.												
Cans/Tins												
Aerosols												
Container Drums												
Sheeting												
Other/Unident.												

Quantitative Litter checklist - Left Bank Cont'd.

Species	Number of Items in Quadrat with Height up Bank											
	1	2	3	4	5	6	7	8	9	10	11	12
Polystyrene												
Sheeting < 30 cm												
Sheeting 30-60 cm												
Sheeting >60 cm												
Plastic Bag												
Sweet Paper												
Bottle												
Other/Unident.												
Bottle												
Other/Unident.												
Cars/Parts of												
Motorbike												
Other/Unident												
Bicycle												
Sign/Cone												
Other/Unident.												
Crate												
Cardboard												
Packaging Strap												
Other/Unident.												
Cloth/Shoe												
Rope/Fishing line												
Other/Unident.												

Quantitative Litter checklist - Right Bank.

Species	Number of Items in Quadrat with Height up Bank											
	1	2	3	4	5	6	7	8	9	10	11	12
Sanitary Towel												
Panty Liner												
Tampon/App.												
Toilet Paper												
Napkin Liner												
Contraceptive												
Cotton Bud												
Other/Unident.												
Fencing												
Hardboard/Wood												
Other/Unident.												
Brick/Rubble												
Floor Cover												
Other/Unident.												
Furniture												
Mattress/Foam												
Other/Unident.												
Fridge/Freezer												
Ceramic Sanitary												
Other/Unident.												
Cans/Tins												
Aerosols												
Container Drums												
Sheeting												
Other/Unident.												

Quantitative Litter checklist - Right Bank Cont'd.

Species	Number of Items in Quadrat with Height up Bank											
	1	2	3	4	5	6	7	8	9	10	11	12
Polystyrene												
Sheeting < 30 cm												
Sheeting 30-60 cm												
Sheeting >60 cm												
Plastic Bag												
Sweet Paper												
Bottle												
Other/Unident.												
Bottle												
Other/Unident.												
Cars/Parts of												
Motorbike												
Other/Unident												
Bicycle												
Sign/Cone												
Other/Unident.												
Crate												
Cardboard												
Packaging Strap												
Other/Unident.												
Cloth/Shoe												
Rope/Fishing line												
Other/Unident.												

A7: Riverine Litter Baseline Survey Form

SURVEY FORM A: BACKGROUND DETAILS	
MONITORING GROUP/PERSON	
CONTACT ADDRESS	
TEL. NO. / FAX. NO.	/

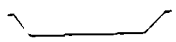
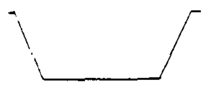
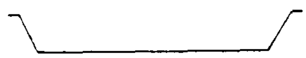
SURVEY DETAILS	
SURVEY DATE	
RIVER NAME	
SITE NAME	
NEAREST TOWN	
COUNTY	
ORDNANCE SURVEY GRID REF.	

REFERENCE INFORMATION
SITE SKETCH
ACCESS VIA

SURVEY FORM B: SITE INFORMATION

LAND USE: Main land-use of site & area 300m radius upstream			
RESIDENTIAL		RESIDENTIAL/COMMERCIAL	
INDUSTRIAL		INDUSTRIAL/COMMERCIAL	
COMMERCIAL		RESIDENTIAL/OPEN SPACE	
OPEN SPACE		INDUSTRIAL/OPEN SPACE	
RESIDENTIAL/INDUSTRIAL		COMMERCIAL/OPEN SPACE	

ROAD NETWORK: Grade of roads at site & area 300m upstream	
DENSE: Presence of 'A' grade roads in area	
MEDIUM: Presence of 'B' grade roads in area	
SPARSE: Presence of ungraded roads in area	
VEHICULAR ACCESS TO RIVER: Road/track within 50m	Y/N

RIVER PROFILE			
			
LOW GRADIENT NARROW CHANNEL		HIGH GRADIENT NARROW CHANNEL	
			
MEDIUM GRADIENT MEDIUM CHANNEL		LOW GRADIENT WIDE CHANNEL	

BANK TYPE	
NATURAL BANKS	
MAN-MADE BANKS	
COMBINATION	

RIVER WIDTH			
<1M		4-8M	
1-2M		>8M	
2-4M			

SURVEY FORM B: SITE INFORMATION			
RIVER DEPTH			
<0.5M		2-4M	
0.5-1M		>4M	
1-2M			

RIVER PATTERN	
TORRENT	
POOL/RIFFLE	
WITHOUT RIFFLE	
MEANDER	
BRAIDED	

VEGETATION DESCRIPTION	
GRADE A (PHOTO A)	
GRADE B (PHOTO B)	
GRADE C (PHOTO C)	
GRADE D (PHOTO D)	

IMMEDIATE POINT SOURCE INPUTS: Within site and 50m upstream		
FLY-TIPPING	INDUSTRIAL TIPPING	
	HOUSEHOLD TIPPING	
	INDUSTRIAL AND HOUSEHOLD TIPPING	
SEWAGE INPUTS: STORM WATER OVERFLOWS		
OTHER: PLEASE SPECIFY		

SURVEY FORM C: LITTER CHECKLIST / TRANSECT No. ___				
FAMILY	GENUS	SPECIES	TALLY	TOTAL
SEWAGE DERIVED	FEMININE HYGIENE	SANITARY TOW.		
		PANTY LINERS		
		TAMPON/APPLI.		
	GENERAL	TOILET PAPER		
		NAPKIN LINERS		
		CONTRACEPTIVE		
		COTTON BUDS		
		OTHER		
BUILDING/ DIY RELATED	COMBUSTIBLE	FENCING		
		HARDBRD/WOOD		
		OTHER		
	NON-COMBUST.	BRICK/RUBBLE		
		FLOOR COVER		
		CERAMIC SANI.		
		OTHER		
CONSUMER DURABLES	BROWN GOODS	FURNITURE		
		TELEVISION		
		OTHER		
	WHITE GOODS	FRIDGE/FREEZ.		
		WASHING MACH.		
		OTHER		
HOUSEHOLD COMMERCIAL INDUSTRIAL	METAL	CANS/TINS		
		AEROSOLS		
		CONTAIN. DRUM		
		SHEETING		
		OTHER		
	PLASTIC	POLYSTYRENE		
		SHEET. <30CM		
		" 30-60CM		
		SHEET. >60CM		

SURVEY FORM C: LITTER CHECKLIST / TRANSECT No. ___				
FAMILY	GENUS	SPECIES	TALLY	TOTAL
		PLASTIC BAGS		
		SWEET PAPERS		
		BOTTLES		
		OTHER		
	GLASS	BOTTLES		
		OTHER		
	TEXTILES	MATTRESSES		
		CLOTH/SHOES		
		CARPETS		
		OTHER		
TRANSPORT ASSOCIATED	MOTOR VEHICLES	CARS/PARTS OF		
		MOTORBIKES/ "		
		OTHER		
	MISCELLANEOUS	BICYCLES		
		SIGNS/CONES		
		OTHER		
GENERAL	PACKAGING	CRATES		
		CARDBOARD		
		PACKAG. STRAPS		
		4 PACK RINGS		
		OTHER		
	MISCELLANEOUS	SHOP TROLLIES		
		ROPE/FISHLINE		
		WIRE/CABLE		
		OTHER		

SURVEY FORM C: LITTER CHECKLIST / TRANSECT No. ___				
FAMILY	GENUS	SPECIES	TALLY	TOTAL
SEWAGE DERIVED	FEMININE HYGIENE	SANITARY TOW.		
		PANTY LINERS		
		TAMPON/APPLI.		
	GENERAL	TOILET PAPER		
		NAPKIN LINERS		
		CONTRACEPTIVE		
		COTTON BUDS		
		OTHER		
BUILDING/ DIY RELATED	COMBUSTIBLE	FENCING		
		HARDBRD/WOOD		
		OTHER		
	NON-COMBUST.	BRICK/RUBBLE		
		FLOOR COVER		
		CERAMIC SANI.		
		OTHER		
CONSUMER DURABLES	BROWN GOODS	FURNITURE		
		TELEVISION		
		OTHER		
	WHITE GOODS	FRIDGE/FREEZ.		
		WASHING MACH.		
		OTHER		
HOUSEHOLD COMMERCIAL INDUSTRIAL	METAL	CANS/TINS		
		AEROSOLS		
		CONTAIN. DRUM		
		SHEETING		
		OTHER		
	PLASTIC	POLYSTYRENE		
		SHEET. <30CM		
		" 30-60CM		
		SHEET. >60CM		

SURVEY FORM C: LITTER CHECKLIST / TRANSECT No. ___

FAMILY	GENUS	SPECIES	TALLY	TOTAL
		PLASTIC BAGS		
		SWEET PAPERS		
		BOTTLES		
		OTHER		
	GLASS	BOTTLES		
		OTHER		
	TEXTILES	MATTRESSES		
		CLOTH/SHOES		
		CARPETS		
		OTHER		
TRANSPORT ASSOCIATED	MOTOR VEHICLES	CARS/PARTS OF		
		MOTORBIKES/ "		
		OTHER		
	MISCELLANEOUS	BICYCLES		
		SIGNS/CONES		
		OTHER		
GENERAL	PACKAGING	CRATES		
		CARDBOARD		
		PACKAG. STRAPS		
		4 PACK RINGS		
		OTHER		
	MISCELLANEOUS	SHOP TROLLIES		
		ROPE/FISHLINE		
		WIRE/CABLE		
		OTHER		

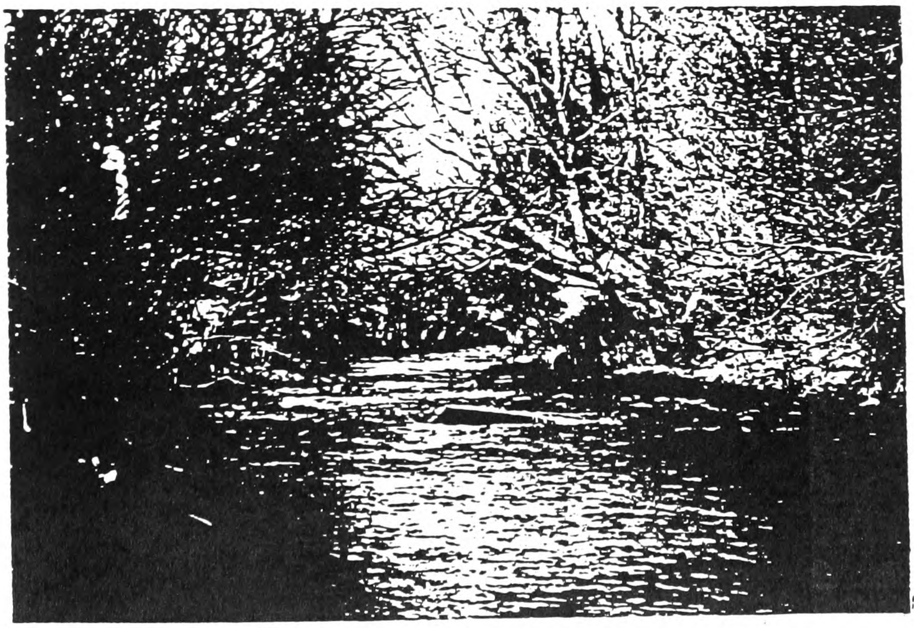
SURVEY FORM C: LITTER CHECKLIST / TRANSECT No. ___				
FAMILY	GENUS	SPECIES	TALLY	TOTAL
SEWAGE DERIVED	FEMININE HYGIENE	SANITARY TOW.		
		PANTY LINERS		
		TAMPON/APPLI.		
	GENERAL	TOILET PAPER		
		NAPKIN LINERS		
		CONTRACEPTIVE		
		COTTON BUDS		
		OTHER		
BUILDING/ DIY RELATED	COMBUSTIBLE	FENCING		
		HARDBRD/WOOD		
		OTHER		
	NON-COMBUST.	BRICK/RUBBLE		
		FLOOR COVER		
		CERAMIC SANI.		
		OTHER		
CONSUMER DURABLES	BROWN GOODS	FURNITURE		
		TELEVISION		
		OTHER		
	WHITE GOODS	FRIDGE/FREEZ.		
		WASHING MACH.		
		OTHER		
HOUSEHOLD COMMERCIAL INDUSTRIAL	METAL	CANS/TINS		
		AEROSOLS		
		CONTAIN. DRUM		
		SHEETING		
		OTHER		
	PLASTIC	POLYSTYRENE		
		SHEET. <30CM		
		" 30-60CM		
		SHEET. >60CM		

SURVEY FORM C: LITTER CHECKLIST / TRANSECT No. ___				
FAMILY	GENUS	SPECIES	TALLY	TOTAL
		PLASTIC BAGS		
		SWEET PAPERS		
		BOTTLES		
		OTHER		
	GLASS	BOTTLES		
		OTHER		
	TEXTILES	MATTRESSES		
		CLOTH/SHOES		
		CARPETS		
		OTHER		
TRANSPORT ASSOCIATED	MOTOR VEHICLES	CARS/PARTS OF		
		MOTORBIKES/ "		
		OTHER		
	MISCELLANEOUS	BICYCLES		
		SIGNS/CONES		
		OTHER		
GENERAL	PACKAGING	CRATES		
		CARDBOARD		
		PACKAG. STRAPS		
		4 PACK RINGS		
		OTHER		
	MISCELLANEOUS	SHOP TROLLIES		
		ROPE/FISHLINE		
		WIRE/CABLE		
		OTHER		

VEGETATION DESCRIPTION

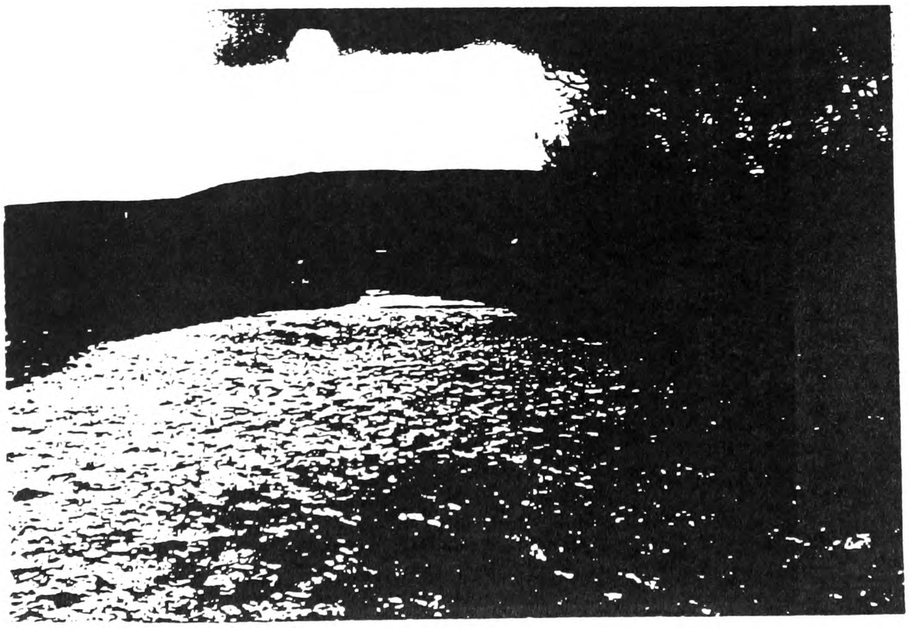
PHOTOGRAPH A: DENSE VEGATATION

PHOTOGRAPH B



PHOTOGRAPH C

PHOTOGRAPH D: SPARSE VEGETATION



Appendix B

Litter Type Key

Sewage Derived	Feminine Hygiene	1	Sanitary Towel
		2	Panty Liner
		3	Tampon
	General	4	Toilet Paper
		5	Napkin Liner
		6	Contraceptive
		7	Cotton Bud
		8	Other
Building/DIY Related	Combustible	9	Fencing
		10	Hardboard/Wood
		11	Other
	Non-combustible	12	Brick/Rubble
		13	Floor Cover
		14	Ceramic Sanitary
		15	Other
Consumer Durables	Brown Goods	16	Furniture
		17	Television
		18	Other
	White Goods	19	Fridge/Freezer
		20	Washing Machine
		21	Other
Household Commercial industrial	Metal	22	Can/Tin
		23	Aerosol
		24	Container Drum
		25	Sheeting
		26	Other
	Plastic	27	Polystyrene
		28	Sheeting < 30 cm
		29	Sheeting 30-60 cm
		30	Sheeting > 60 cm
		31	Plastic Bag
		32	Sweet Paper
		33	Bottle
		34	Other
	Glass	35	Bottle
		36	Other
	Textiles	37	Mattress
		38	Cloth/Shoe
		39	Carpet
		40	Other
Transport Associated	Motor Vehicle	41	Car/Parts
		42	Motorbike/Parts
		43	Other
	Miscellaneous	44	Bicycles
		45	Sign/Cone
		46	Other
General	Packaging	47	Crate
		48	Cardboard
		49	Packaging Strap
		50	4 Pack Ring
		51	Other
	Miscellaneous	52	Shopping Trolley
		53	Rope/Fishline
		54	Wire/Cable
		55	Other

Table B1. River Taff Site Location and Physical Characteristics

River	Site	Town	Grid Ref.	Land Use	Road Network	Access	Profile	Bank	Width	Depth	Pattern	Vegetation	Fly-tipping	Sewage
Taff Fawr	1:Welsh Water St.	Brecon	SO 013 111	9	3	1	1	1	4	2	2	3	1	0
Taff Fawr	2:Cefn Coed Y.	Merthyr	SO 029 077	8	3	1	2	1	4	2	2	2	2	0
Taff Fechan	3:Near Bridge	Ponsticill	SO 059 115	9	3	1	1	1	4	1	2	3	0	0
Taff Fechan	4:Old Sewage W.	Trefechan	SO 040 912	4	3	0	1	1	4	2	2	4	0	1
Taff Fechan	5:Gwynnes Arms	Pont-y-Cefn	SO 038 076	8	1	1	2	1	5	2	2	2	0	0
Taff	6:Industrial Est.	Abercanaid	SO 056 039	7	3	1	2	3	5	3	2	2	2	0
Taff	7:School	Troedyrhiw	SO 071 021	1	2	0	2	1	5	2	2	1	2	0
Taff	8:Fish & Chip Sh.	Aberfan	ST 075 997	1	2	0	2	1	5	3	2	3	0	0
Taff	9:Edwardsville	Edwardsville	ST 090 965	4	3	1	2	1	4	3	2	3	0	0
Taff	10:Quakers Yard	Quakers Yard	ST 095 963	7	1	1	2	1	5	3	2	3	2	1
Taff	11:First Lay-By	Abercynon	ST 087 952	4	1	1	2	1	5	3	2	2	3	0
Taff	12:Coed-y-Cwm	Abercynon	ST 082 930	5	3	1	2	3	4	3	2	3	1	1
Taff	13:Ponty Park	Pontypridd	ST 075 897	4	1	0	2	3	5	4	1	2	0	0
Taff	14: d/s Ponty Park	Pontypridd	ST 073 899	10	1	0	2	3	5	4	1	3	1	1
Taff	15:Treforest Park	Treforest	ST 084 895	7	1	0	2	2	5	3	2	2	2	1
Taff	16:Rhydyfelin	Rhydyfelin	ST 094 891	5	1	1	2	1	5	4	1	2	2	0
Taff	17:School Field	Hawthorn	ST 100 873	5	3	1	2	3	5	4	1	4	0	0
Taff	18:Industrial Est.	Tref. Ind. Est.	ST 108 863	9	1	0	2	1	5	4	1	2	2	0
Taff	19:Phoenix	Tref. Ind. Est.	ST 111 859	9	1	1	2	3	5	3	2	4	1	1
Taff	20:Pub	Taffs Well	ST 118 837	7	3	1	2	3	5	4	1	2	0	0
Taff	21:Ynys Bridge	Radyr	ST 127 826	10	1	1	2	3	4	3	2	4	0	0
Taff	22:Radyr Weir	Radyr	ST 132 807	10	2	0	4	1	5	4	1	3	0	0
Taff	23:Housing Est.	Whitchurch	ST 142 800	8	3	0	4	3	5	4	1	3	0	1
Taff	24:Radyr Court	Llandaff North	ST 144 793	8	3	1	2	1	5	4	3	3	2	0
Taff	25:Llandaff Weir	Llandaff North	ST 154 785	8	3	0	4	1	5	4	2	3	0	0
Taff	26:Taff Terrace	Grangetown	ST 183 749	5	1	1	4	3	5	4	4	4	3	0
Cynon	27:Ford	Penderyn	SN 952 081	4	1	1	1	1	2	1	2	3	0	0
Cynon	28:Police Station	Hirwaun	SN 956 059	4	3	1	1	1	3	3	2	3	2	0
Cynon	29:Housing Est.	Hirwaun	SN 966 054	4	3	1	1	1	4	3	2	3	0	1
Cynon	30:Housing Est.	Penywaun	SN 979 049	8	3	1	1	1	4	3	2	2	2	0

Table B1 (Cont'd). River Taff Site Location and Physical Characteristics

River	Site	Town	Grid Ref.	Land Use	Road Network	Access	Profile	Bank	Width	Depth	Pattern	Vegetation	Fly-tipping	Sewage
Cynon	31:Level Crossing	Robertstown	SN 996 038	1	1	0	2	1	4	2	2	2	0	0
Cynon	32:Aman Conf.	Aberdare	SO 021 012	4	1	0	2	3	4	3	2	2	0	1
Cynon	33:Opp. School	Mt. Ash	ST 039 995	4	1	0	2	1	4	2	2	2	0	1
Cynon	34:AB Electronics	Ynysboeth	ST 073 967	9	1	1	2	1	5	2	2	2	0	0
Cynon	35:Ind. Estate	Abercynon	ST 077 959	2	2	1	2	1	5	4	3	2	1	1
Cynon	36:Road Bridge	Abercynon	ST 084 952	1	3	1	2	3	4	2	2	3	0	0
Rhondda Fach	37:Maerdy	Maerdy	SS 976 984	8	2	1	1	3	4	1	2	4	3	1
Rhondda Fach	38:Ferndale	Ferndale	SS 998 975	8	3	1	3	3	4	2	2	3	2	0
Rhondda Fach	39:Nr. School	Ferndale	ST 001 971	1	3	1	2	3	3	2	2	4	0	1
Rhondda Fach	40:u/s Rail. Cross	Tylorstown	ST 012 954	8	3	1	2	3	4	2	2	3	0	0
Rhondda Fach	41:Rail. Bridge	Ynyshir	ST 026 929	1	3	1	2	1	4	3	2	3	2	0
Rhondda Fawr	42:Town	Blaenrhondda	SS 928 997	1	2	1	3	3	4	2	2	4	0	0
Rhondda Fawr	43:Bute Arms	Treherbert	SS 939 984	8	1	1	3	3	4	2	2	3	0	0
Rhondda Fawr	44:Nr. Green	Pen-yr-Englyn	SS 944 978	4	1	1	3	3	4	2	2	4	1	0
Rhondda Fawr	45:Rail. Crossing	Ton Pentre	SS 970 956	1	2	0	2	3	5	2	2	3	0	0
Rhondda Fawr	46:Llwynypia	Llwynypia	SS 997 943	1	1	1	3	1	4	2	2	3	2	0
Rhondda Fawr	47:Gelli Crossing	Ystrad	SS 980 952	1	1	1	3	3	5	3	2	2	0	0
Rhondda Fawr	48:Burberry Fac.	Ynyswen	SS 951 974	5	1	1	3	3	4	2	2	2	3	0
Rhondda Fawr	49:u/s Station	Dinas	SS 997 923	4	1	1	2	3	4	2	2	3	2	1
Rhondda	50:Lodge Pub	Porth	ST 034 910	7	1	1	2	3	4	3	2	3	2	0

Table B2. River Taff Summer Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	17/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	17/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	17/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	17/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	17/05/92	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
6	17/05/92	3	1	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0
		3	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0
		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	17/05/92	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	17/05/92	5	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0
		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		6	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	13/05/92	4	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	13/05/92	8	3	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		12	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	2	4	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0
11	13/05/92	2	0	2	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
		4	1	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0
		6	3	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
12	07/05/92	10	3	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		6	3	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		6	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	13/05/92	1	1	0	0	0	0	0	0	0	2	0	0	1	0	1	0	0	0	0
		5	2	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0
		5	1	1	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0
14	13/05/92	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
		9	2	0	0	0	0	0	0	0	3	0	0	0	2	0	0	0	0	0
		3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
15	07/05/92	21	11	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		22	13	6	0	1	0	0	0	0	3	0	1	1	0	0	0	0	0	0
16	13/05/92	8	5	1	0	0	0	0	0	0	3	0	1	0	0	0	1	0	0	0
		4	1	3	0	0	0	14	0	0	2	0	0	2	0	1	0	0	0	0
		2	1	0	0	0	0	3	0	0	1	0	0	1	0	0	0	0	0	0
17	12/05/92	5	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
		1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B2 (Cont'd). River Taff Summer Baseline Survey Raw Data

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	17/05/92	0	0	0	0	0	0	2	0	3	2	1	1	2	2	1	0	0	0	0
		0	0	0	0	0	0	0	0	0	2	1	1	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	2	1	0	2	0	0	1	0	0	0
2	17/05/92	0	0	0	0	0	0	0	0	1	3	2	3	2	0	1	0	0	0	2
		0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	1	0	0	0	0	0	2	0	1	1	0	1	0	0	0	0	0
3	17/05/92	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	17/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	17/05/92	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	2	0	2	3	0	1	0	1	0	0	0	1
		0	0	1	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	1
6	17/05/92	0	0	2	0	0	0	0	5	6	4	6	2	4	1	0	1	0	0	0
		0	0	1	0	0	0	0	0	3	3	5	1	5	0	0	1	1	0	0
		0	0	1	0	0	0	0	0	2	1	0	0	3	0	0	0	0	0	0
7	17/05/92	0	0	0	0	0	0	0	0	2	5	1	1	1	0	1	0	0	0	0
		0	0	0	0	0	1	0	0	6	4	5	1	1	0	0	0	2	0	3
		0	0	0	0	0	0	0	0	2	6	5	2	3	0	0	0	0	0	1
8	17/05/92	0	0	0	0	0	1	0	0	5	1	1	0	3	0	0	0	0	0	0
		0	0	0	0	0	0	0	2	1	1	0	0	1	0	0	2	0	0	1
		0	0	1	0	0	0	1	0	3	1	0	0	4	1	0	1	0	0	2
9	13/05/92	0	0	0	0	0	0	0	1	2	2	4	0	1	0	1	0	0	0	2
		0	0	0	0	0	0	1	0	5	4	1	1	3	1	0	0	0	0	3
		0	0	0	0	0	0	0	1	4	3	1	0	1	0	1	2	0	0	0
10	13/05/92	0	0	6	0	0	0	0	0	7	12	4	3	7	0	0	1	0	0	10
		0	0	4	0	0	0	0	0	2	3	4	0	1	0	1	0	0	0	7
		0	0	3	0	0	0	0	0	2	3	5	1	3	0	2	2	0	0	5
11	13/05/92	0	0	1	0	1	0	0	0	1	1	0	1	1	0	0	1	0	0	0
		0	0	2	0	0	0	2	1	3	4	2	1	2	0	0	3	1	0	2
		0	0	0	0	0	0	2	1	2	4	4	0	1	0	1	3	1	0	11
12	07/05/92	0	0	0	0	0	0	0	1	3	4	2	1	3	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	11	8	3	0	0	0	0	0	0	0	3
		0	0	0	1	0	0	0	2	4	6	2	0	1	0	0	0	0	0	0
13	13/05/92	0	0	4	0	0	0	0	0	3	2	1	3	1	0	0	2	0	0	4
		0	0	0	0	0	0	1	0	4	5	4	0	2	0	2	2	0	0	3
		0	0	1	0	1	2	1	4	5	2	1	0	1	0	2	3	0	0	4
14	13/05/92	0	0	0	0	0	0	0	0	0	2	5	0	2	2	0	0	0	0	1
		0	0	1	0	1	0	3	0	3	4	3	2	3	0	0	0	0	0	5
		0	0	1	0	0	1	0	1	3	1	0	0	3	0	2	0	0	0	2
15	07/05/92	0	0	0	0	0	0	0	0	8	8	16	9	16	0	0	0	1	0	6
		0	0	1	0	0	0	2	0	2	4	7	6	3	0	0	1	0	0	5
		0	0	2	0	0	0	1	0	11	16	15	7	13	0	0	2	1	0	3
16	13/05/92	0	0	3	1	1	0	0	3	4	6	14	1	8	3	3	6	0	0	7
		0	0	7	2	0	0	0	12	2	3	7	3	4	2	0	7	0	0	3
		0	0	2	0	0	0	0	2	2	2	4	1	2	0	0	8	0	1	0
17	12/05/92	0	0	2	0	0	0	0	0	3	4	2	0	2	0	1	1	0	0	5
		0	0	0	0	0	0	0	1	2	0	0	0	3	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0	0	4

Table B2 (Cont'd). River Taff Summer Baseline Survey Raw Data

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1	17/05/92	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	17/05/92	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
3	17/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	17/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	17/05/92	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
6	17/05/92	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	17/05/92	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	17/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	13/05/92	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	13/05/92	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0
11	13/05/92	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	2	0
		0	0	2	0	0	0	0	0	0	0	0	0	0	1	1	6	0
		1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	07/05/92	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	13/05/92	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	4	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	13/05/92	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		1	0	1	0	0	0	0	0	0	0	0	0	0	1	3	4	0
		0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	0
15	07/05/92	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	3	0
		1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	1	0
		0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	2	0
16	13/05/92	0	0	0	0	0	0	0	0	0	0	3	1	1	0	1	0	0
		0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
17	12/05/92	0	0	0	0	0	1	0	0	0	2	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B2 (Cont'd). River Taff Summer Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
18	12/05/92	4	1	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0
		2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		7	3	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0
19	07/05/92	4	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		10	3	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
20	12/05/92	9	1	2	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	0
		7	3	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		6	3	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
21	06/05/92	12	4	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		9	4	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	12/05/92	6	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		12	5	2	0	0	0	1	0	0	6	0	0	0	0	0	0	0	0	0
		10	6	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
23	12/05/92	8	3	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		11	5	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		3	0	0	0	0	0	5	0	0	4	0	0	0	1	0	0	0	0	0
24	06/05/92	2	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
		5	2	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		8	3	1	0	0	0	2	0	0	1	0	0	1	0	0	0	0	0	0
25	12/05/92	5	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	0	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
26	06/05/92	1	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		1	0	0	0	0	0	2	0	0	3	0	0	0	0	0	0	0	0	0
27	14/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	14/05/92	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
		0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	14/05/92	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	1	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0
30	14/05/92	4	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	14/05/92	2	1	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		1	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
32	14/05/92	14	4	2	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0
		13	7	3	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
		16	5	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
33	07/05/92	9	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	3	3	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
34	07/05/92	7	3	1	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0
		8	3	2	0	0	0	2	0	0	5	0	0	0	0	0	0	0	0	0
		15	4	1	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0

Table B2 (Cont'd). River Taff Summer Baseline Survey Raw Data

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
18	12/05/92	0	0	2	0	0	0	0	0	3	2	3	1	1	1	0	0	0	0	0
		0	0	2	0	0	2	0	1	5	1	1	1	0	1	0	0	0	0	3
		0	0	1	0	0	0	0	4	6	3	5	4	0	1	2	3	0	0	0
19	07/05/92	0	0	0	0	0	0	0	0	4	4	5	2	1	0	1	1	3	0	4
		0	0	0	0	0	0	0	1	6	8	2	2	2	0	1	0	0	0	4
		0	0	1	0	0	1	1	0	6	12	16	7	9	0	2	1	1	0	9
20	12/05/92	0	0	15	0	0	1	0	0	1	3	2	1	3	0	2	0	0	0	3
		0	0	17	0	3	0	0	1	3	0	2	1	2	1	2	0	0	0	2
		0	0	9	0	0	0	0	1	6	3	1	2	1	0	2	0	0	0	7
21	06/05/92	0	0	1	0	0	0	0	1	3	3	1	2	3	0	0	0	0	0	0
		0	0	0	0	0	1	0	0	0	1	1	0	3	0	0	2	0	0	0
		0	0	4	0	0	0	1	0	2	1	0	1	2	0	0	0	0	0	0
22	12/05/92	0	0	3	0	0	0	0	6	3	2	2	5	1	1	0	0	0	0	6
		0	0	1	1	0	0	0	0	2	5	9	1	2	2	1	2	0	0	7
		0	0	1	0	1	0	0	1	3	6	8	5	1	1	1	0	0	0	2
23	12/05/92	0	0	0	0	0	0	1	5	3	4	6	0	0	1	0	1	0	0	1
		0	0	0	0	0	0	0	3	4	5	6	2	2	2	2	0	1	0	4
		0	0	0	3	2	0	0	7	1	4	3	2	3	5	2	0	2	0	0
24	06/05/92	0	0	0	1	0	0	0	11	2	3	2	0	9	3	0	1	0	0	1
		0	0	4	0	0	3	0	7	3	4	9	4	8	1	0	6	0	0	5
		0	0	3	0	0	3	0	7	0	4	11	3	3	2	3	1	0	0	19
25	12/05/92	0	0	1	0	0	0	0	1	6	1	1	1	2	0	0	0	0	0	1
		0	0	0	0	0	0	0	4	2	2	2	3	6	1	1	0	0	0	0
		0	0	0	0	0	0	0	2	3	3	2	0	4	2	0	1	0	0	1
26	06/05/92	0	0	2	0	1	0	0	3	0	2	2	1	2	0	0	5	0	0	0
		0	0	3	0	0	2	1	4	1	1	1	2	2	0	0	3	0	0	1
		0	0	3	2	0	1	0	6	0	0	3	6	6	4	2	2	0	0	2
27	14/05/92	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	14/05/92	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	3
		0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0
		0	0	1	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0
29	14/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	1	0	0	0	1	3	2	6	1	2	1	1	0	0	0	1
		0	0	1	0	0	0	0	0	0	2	4	1	4	0	1	0	0	0	2
30	14/05/92	0	0	1	0	0	0	0	0	1	1	4	0	3	0	1	0	0	0	1
		0	0	0	0	0	0	0	1	2	3	2	1	8	0	0	3	0	0	2
		0	0	1	0	0	0	0	1	0	1	0	0	1	0	1	2	0	0	1
31	14/05/92	0	0	0	0	0	4	0	1	7	1	1	1	2	0	2	0	0	0	2
		0	0	0	0	1	0	0	0	1	4	2	0	0	0	1	0	0	0	0
		0	0	0	0	0	3	0	0	2	3	2	0	0	0	0	0	0	0	2
32	14/05/92	0	0	0	0	0	0	0	0	3	8	2	1	2	1	0	0	0	0	3
		0	0	2	0	0	0	0	0	2	11	4	3	6	0	0	0	0	0	3
		0	0	0	0	0	0	0	2	3	1	4	1	3	1	0	0	0	0	6
33	07/05/92	0	0	0	0	0	0	0	0	3	2	3	0	2	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	2	0	0	1
		0	0	0	0	0	0	0	1	3	6	3	0	2	0	0	2	1	0	2
34	07/05/92	0	0	0	0	0	0	0	4	2	1	1	0	4	1	0	0	0	0	1
		0	0	0	0	0	0	0	9	2	2	2	0	4	0	0	0	0	0	2
		0	0	0	0	0	0	0	5	4	6	4	1	4	0	0	0	0	0	1

Table B2 (Cont'd). River Taff Summer Baseline Survey Raw Data

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
18	12/05/92	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
		1	0	1	0	0	0	0	0	0	0	2	0	0	0	0	1	0
		0	0	1	1	0	0	0	0	1	0	0	0	0	1	2	0	0
19	07/05/92	0	0	1	0	0	0	0	0	0	0	5	1	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
		1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	5	0
20	12/05/92	2	0	3	0	0	1	0	0	0	0	2	0	0	0	0	6	0
		1	0	3	1	0	1	0	0	0	0	0	0	0	0	0	2	0
		1	0	1	0	0	0	0	0	0	1	0	1	0	0	1	1	0
21	06/05/92	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
22	12/05/92	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
		3	0	0	0	0	0	0	0	0	0	1	0	0	0	2	3	0
		0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
23	12/05/92	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	06/05/92	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0
		2	0	0	0	0	0	0	0	0	0	5	0	0	0	0	2	0
25	12/05/92	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
26	06/05/92	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0
		1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	0
27	14/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	14/05/92	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	14/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	14/05/92	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	14/05/92	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	2	0
32	14/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	07/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	07/05/92	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0

Table B2 (Cont'd). River Taff Summer Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
35	18/05/92	6	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
36	07/05/92	3	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0
		3	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	18/05/92	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
		2	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
38	18/05/92	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	1	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0
39	08/05/92	4	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	08/05/92	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	08/05/92	3	1	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
		1	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		3	0	0	0	0	0	0	0	0	16	0	0	0	0	3	0	0	0	0
42	15/05/92	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	15/05/92	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
44	15/05/92	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	15/05/92	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	08/05/92	5	2	0	0	0	0	0	0	2	2	2	0	0	1	0	0	0	0	0
		1	0	0	0	0	0	1	0	1	4	0	0	10	0	0	0	0	0	0
		5	3	0	0	1	0	0	0	0	4	0	0	0	0	0	0	0	0	0
47	18/05/92	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	15/05/92	5	2	3	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0
		4	0	1	0	0	0	0	0	0	4	0	0	2	0	0	1	0	0	0
		7	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	08/05/92	12	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		6	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
50	08/05/92	2	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		4	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
		2	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0

Table B2 (Cont'd). River Taff Summer Baseline Survey Raw Data

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
35	18/05/92	0	0	1	0	0	0	2	0	3	2	4	0	2	0	0	1	0	0	1
		0	0	1	0	0	1	0	0	2	3	5	0	4	2	0	3	0	0	1
		0	0	1	0	1	0	1	0	1	5	2	1	1	1	2	5	2	0	1
36	07/05/92	0	0	0	0	0	0	0	0	1	0	1	0	2	1	0	0	0	0	0
		0	0	1	0	0	0	0	0	1	0	2	0	4	1	0	0	0	0	1
		0	0	1	0	0	0	0	0	1	2	0	1	1	0	0	0	0	0	0
37	18/05/92	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1
		0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0	0	0
		0	0	0	0	0	1	1	0	2	1	0	0	2	0	0	1	0	0	0
38	18/05/92	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	2	3	1	2	0	2	0	0	0	0	0	0
39	08/05/92	0	0	0	0	0	0	0	2	4	1	1	0	8	1	1	0	0	0	1
		0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0
		0	0	3	0	0	0	0	5	2	0	0	0	2	0	0	0	0	0	0
40	08/05/92	0	0	1	0	0	0	0	3	2	3	2	0	16	3	0	0	0	0	1
		0	0	1	0	0	0	0	5	5	4	0	1	16	1	0	0	0	0	0
		0	0	1	0	0	0	0	1	2	3	3	1	10	2	0	0	0	0	1
41	08/05/92	0	0	5	0	0	0	0	2	7	3	4	8	10	1	0	2	0	0	1
		0	0	1	0	0	1	0	3	5	11	5	6	21	0	2	1	1	0	0
		0	0	4	0	0	2	1	0	2	3	4	4	3	2	2	1	1	0	2
42	15/05/92	0	0	0	0	0	0	0	1	3	0	0	0	2	0	0	0	0	0	0
		0	0	2	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	1
		0	0	1	0	0	0	0	1	3	1	1	0	4	0	0	0	0	0	0
42	15/05/92	0	0	2	0	0	0	0	0	5	3	1	0	15	0	1	0	0	0	0
		0	0	5	0	0	0	0	7	4	3	2	1	18	1	0	0	0	0	3
		0	0	3	0	0	0	0	6	5	5	3	3	14	2	0	3	0	0	0
44	15/05/92	0	0	0	0	0	0	0	0	3	0	1	1	1	1	0	0	0	0	1
		0	0	0	0	0	1	1	1	2	0	0	1	1	0	1	1	0	0	0
		0	0	2	0	0	0	0	0	2	0	0	0	5	0	1	2	0	0	1
45	15/05/92	0	0	2	0	0	0	0	2	4	4	1	2	5	0	0	1	0	0	0
		0	0	0	0	0	0	0	1	3	1	0	0	2	0	0	0	0	0	0
		0	0	0	0	1	0	0	1	0	3	1	0	7	0	0	3	0	0	0
46	08/05/92	0	0	0	0	0	1	0	3	3	4	5	3	6	1	0	1	0	0	0
		0	0	3	0	0	0	0	2	4	4	4	3	10	0	0	1	0	0	0
		0	0	0	0	0	0	1	5	0	3	0	1	8	0	0	1	0	1	3
47	18/05/92	0	0	6	0	0	0	0	0	3	5	7	2	1	0	0	0	0	0	2
		0	0	6	0	0	0	0	3	1	1	3	3	11	0	0	0	0	0	2
		0	0	4	0	0	0	0	2	3	2	2	2	6	1	0	2	0	0	1
48	15/05/92	0	0	2	0	0	0	0	0	3	8	14	3	4	3	0	1	0	0	7
		0	0	7	0	1	0	0	1	2	4	8	2	7	5	2	4	0	0	2
		0	0	2	0	0	0	0	1	3	6	8	3	5	1	0	0	0	0	0
49	08/05/92	0	0	0	0	0	0	2	2	5	5	7	2	7	0	0	0	0	0	0
		0	0	0	0	0	0	0	3	2	1	0	0	5	0	0	0	0	0	0
		0	0	0	0	0	0	1	2	3	0	2	0	3	0	0	1	0	0	0
50	08/05/92	0	0	3	0	0	1	0	1	6	0	2	1	8	0	0	0	0	0	0
		0	0	2	0	0	0	1	4	8	5	2	4	3	2	1	0	0	0	0
		0	0	3	0	0	0	0	7	5	2	2	0	6	0	0	1	0	0	0

Table B2 (Cont'd). River Taff Summer Baseline Survey Raw Data

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
35	18/05/92	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
36	07/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
37	18/05/92	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0
		0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0
38	18/05/92	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	3	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	08/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	08/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	08/05/92	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
42	15/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0
42	15/05/92	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	2	0
		0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0
44	15/05/92	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
		0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	3	0
45	15/05/92	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	1	1
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
46	08/05/92	0	0	3	0	0	1	0	0	0	0	1	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	2	1	1	0	0	0	3	0
		1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	1	0
47	18/05/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
		0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	15/05/92	2	0	1	0	0	0	1	0	0	0	0	1	0	0	2	1	0
		3	0	1	0	0	1	0	0	2	0	0	0	0	0	2	1	1
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
49	08/05/92	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
50	08/05/92	0	0	2	0	0	0	0	0	0	1	0	0	1	0	0	0	0
		1	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B3. River Taff Winter Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	12/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	12/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	12/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	12/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	12/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	2	0	0	1	0	1	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	12/03/93	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		14	3	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
		4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	15/03/93	5	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		5	2	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
		8	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	15/03/93	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	15/03/93	13	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		9	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	15/03/93	7	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		16	10	1	0	1	2	0	0	0	0	0	0	2	0	0	0	0	0	0
		6	2	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
11	15/03/93	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	15/03/93	9	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		5	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
13	15/03/93	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	15/03/93	4	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	18/03/93	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		10	3	2	0	0	0	0	0	1	1	0	0	2	0	1	0	0	0	0
		10	4	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
16	18/03/93	16	3	2	0	1	0	1	0	1	2	0	0	0	1	4	2	0	0	0
		5	1	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		6	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	18/03/93	11	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B3 (Cont'd). River Taff Winter Baseline Survey Raw Data

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	12/03/93	0	0	0	0	0	1	1	0	3	2	1	0	1	1	0	0	0	0	0
		0	0	0	0	0	0	2	0	0	3	3	0	0	0	1	0	0	0	0
		0	0	0	0	0	0	0	0	2	1	0	1	0	0	1	0	0	0	0
2	12/03/93	0	0	0	0	0	0	0	0	1	4	3	3	0	0	1	0	0	0	1
		0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	1	0	0	0
		0	0	2	0	0	0	0	0	2	1	3	0	0	0	0	0	0	0	0
3	12/03/93	0	0	1	0	0	0	0	2	0	1	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0
		0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0
4	12/03/93	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	12/03/93	0	0	0	0	0	0	0	0	3	2	0	0	1	1	0	0	0	0	0
		0	0	1	0	0	0	0	0	4	1	1	1	0	0	0	0	0	0	0
		0	0	1	0	0	0	0	0	0	0	3	1	1	0	0	0	0	0	2
6	12/03/93	0	0	2	1	0	0	3	7	5	2	3	0	2	0	0	0	2	0	6
		0	0	0	0	0	0	0	0	4	4	2	0	0	0	0	1	0	0	0
		0	0	1	0	0	0	0	0	5	1	0	1	4	0	0	0	0	0	0
7	15/03/93	0	0	1	0	0	0	0	0	4	4	0	3	1	0	1	0	0	0	3
		0	0	0	0	0	0	0	0	3	2	3	1	2	0	1	0	1	0	2
		0	0	2	0	0	0	0	0	2	2	0	3	2	0	1	0	0	0	3
8	15/03/93	0	0	1	0	0	0	0	0	5	2	0	1	2	0	1	0	0	0	4
		0	0	0	0	0	0	0	0	6	2	3	2	3	0	1	0	0	0	4
		0	0	0	0	0	0	0	0	1	0	1	2	1	0	0	0	0	0	2
9	15/03/93	0	0	1	0	0	0	0	0	7	3	6	1	1	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	6	7	4	1	3	1	0	0	0	0	3
		0	0	2	0	0	1	0	2	6	4	2	1	3	0	0	1	0	0	0
10	15/03/93	0	0	0	0	0	0	0	0	6	4	2	2	1	0	0	0	0	0	4
		0	0	8	0	1	1	0	0	2	3	2	3	2	1	2	0	0	0	10
		0	0	4	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	3
11	15/03/93	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	3
		0	0	0	0	0	2	1	0	4	5	1	1	1	0	0	0	0	0	2
		0	0	0	0	0	1	1	0	2	3	1	0	1	0	1	0	1	0	2
12	15/03/93	0	0	2	0	0	1	1	0	5	5	2	2	2	0	0	0	0	0	2
		0	0	0	0	0	2	0	0	1	2	0	1	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	1	3	5	2	0	0	0	0	0	0	0	3
13	15/03/93	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0
		0	0	3	0	0	0	1	0	3	1	0	0	1	0	0	1	0	0	0
		0	0	0	0	0	1	0	0	0	1	1	0	0	0	2	0	0	0	1
14	15/03/93	0	0	6	0	0	0	1	0	0	4	1	1	0	0	1	0	0	0	6
		0	0	1	0	0	0	1	0	1	2	1	3	1	0	0	0	0	0	3
		0	0	0	0	0	0	0	0	1	3	1	2	0	0	0	0	0	0	0
15	18/03/93	1	0	0	0	0	1	1	0	4	9	2	1	0	0	2	0	0	0	3
		0	0	3	0	0	1	0	3	3	7	7	5	1	0	0	0	0	2	11
		0	0	1	0	0	1	2	0	5	7	7	7	5	1	0	0	0	0	9
16	18/03/93	0	1	0	0	1	1	0	5	12	17	7	6	8	1	0	6	0	0	13
		0	0	2	0	2	0	1	1	4	10	5	3	4	1	1	3	0	0	6
		0	0	2	1	0	0	0	1	1	5	7	1	2	0	0	7	0	0	3
17	18/03/93	0	0	3	0	0	0	0	1	8	7	2	0	6	0	2	0	0	0	3
		0	0	0	0	0	0	0	0	1	4	0	3	5	0	1	0	0	0	1
		0	0	1	0	0	0	0	0	6	10	1	1	7	0	2	0	0	1	6

Table B3 (Cont'd). River Taff Winter Baseline Survey Raw Data

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1	12/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
2	12/03/93	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
3	12/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
4	12/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	12/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	12/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
7	15/03/93	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	15/03/93	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	2	0
		1	0	2	0	0	0	0	0	0	0	0	0	0	1	0	3	1
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
9	15/03/93	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	15/03/93	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0
		2	0	3	0	0	2	0	0	0	0	1	0	0	0	1	3	0
		1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	6	0
11	15/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
		1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	2	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
12	15/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	15/03/93	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
14	15/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		2	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	18/03/93	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0
		5	0	0	0	0	0	0	0	0	0	1	0	0	0	2	10	0
		5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4	1
16	18/03/93	2	0	0	0	0	0	0	0	4	0	3	1	0	0	0	3	1
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
17	18/03/93	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Table B3 (Cont'd). River Taff Winter Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
18	16/03/93	5	2	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		11	3	2	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0
19	16/03/93	7	2	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		7	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		9	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	16/03/93	3	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
		5	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
		6	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
21	16/03/93	12	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	16/03/93	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		2	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0
		8	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	16/03/93	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	16/03/93	1	0	2	0	0	0	0	0	0	0	1	0	0	2	0	1	0	0	0
		8	3	1	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0
		3	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
25	16/03/93	6	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		5	0	2	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0
		12	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	16/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
27	26/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	26/02/93	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	26/02/93	11	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	26/02/93	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		3	0	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
31	26/02/93	1	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0
		1	0	0	0	2	0	0	0	0	1	1	0	1	0	1	0	0	0	0
		2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
32	26/02/93	8	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	1	2	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0
		10	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	26/02/93	9	2	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
		15	3	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		15	7	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0
34	25/02/93	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5	1	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		11	4	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0

Table B3 (Cont'd). River Taff Winter Baseline Survey Raw Data

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
18	16/03/93	0	0	0	0	0	1	0	1	6	2	4	2	0	0	1	0	0	0	6
		0	0	6	0	0	0	0	1	6	7	3	1	1	1	0	0	0	0	5
		0	0	1	1	0	1	0	1	2	8	2	1	2	0	0	0	0	1	6
19	16/03/93	0	0	0	0	0	1	1	0	6	6	3	3	1	0	1	0	0	0	3
		0	0	0	0	0	0	1	0	4	7	5	2	0	0	2	0	0	0	8
		0	0	2	0	0	0	0	0	2	6	5	4	1	0	1	0	0	0	3
20	16/03/93	0	0	15	0	1	1	1	0	3	5	5	0	0	0	4	0	1	1	9
		0	0	4	0	0	0	0	0	0	1	2	2	1	0	0	0	0	0	5
		0	0	7	0	0	0	0	0	4	4	1	1	0	0	0	0	0	0	4
21	16/03/93	0	0	0	0	0	2	0	0	4	6	1	2	0	0	0	0	0	0	3
		0	0	0	0	0	0	0	0	1	3	0	0	0	0	1	0	0	0	1
		0	0	0	0	0	0	0	0	3	3	2	0	3	0	0	0	0	0	3
22	16/03/93	0	0	3	0	0	0	0	2	2	3	4	1	0	0	0	0	0	0	1
		0	0	4	0	0	1	0	1	3	5	2	2	2	0	0	0	0	1	1
		0	0	4	0	0	0	0	1	5	6	6	1	1	0	1	0	0	1	8
23	16/03/93	0	0	0	0	1	1	1	0	0	3	8	0	0	1	0	0	0	0	0
		0	0	0	0	2	0	0	0	2	2	1	0	0	0	2	0	1	0	3
		0	0	0	0	0	0	2	1	2	5	1	0	0	0	0	0	0	0	2
24	16/03/93	0	0	2	0	0	0	0	1	5	5	4	2	1	0	1	0	3	0	9
		0	0	2	0	0	0	0	0	3	5	4	3	0	0	2	0	0	0	11
		0	0	0	0	0	0	0	3	2	6	7	2	4	0	0	0	0	0	3
25	16/03/93	0	0	0	0	0	0	0	0	3	2	1	0	1	0	0	0	0	0	5
		0	0	0	0	0	0	0	1	4	0	0	1	1	0	1	0	0	0	1
		0	0	0	0	0	0	0	2	7	7	7	3	9	0	0	0	0	1	0
26	16/03/93	0	0	1	0	0	0	0	2	2	0	0	0	0	1	1	0	0	0	0
		0	0	4	0	0	0	0	7	0	1	0	0	2	1	1	2	0	0	0
		0	0	3	0	0	0	1	6	1	1	3	0	2	3	2	0	0	0	0
27	26/02/93	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
28	26/02/93	0	0	2	0	0	0	0	0	1	1	2	0	1	0	1	0	0	0	0
		0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
29	26/02/93	0	0	0	0	0	0	0	0	5	6	1	0	1	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1
		0	0	0	0	0	0	0	0	3	4	6	3	3	0	1	0	0	0	0
30	26/02/93	0	0	0	0	0	0	0	0	2	3	1	3	5	0	0	1	0	0	0
		0	0	0	0	0	0	1	0	4	1	1	0	2	0	0	0	0	0	1
		0	0	4	0	0	0	0	0	2	3	5	3	2	0	0	0	0	0	1
31	26/02/93	0	0	0	0	0	2	1	0	1	2	0	1	1	0	3	0	0	0	0
		0	0	1	0	0	2	1	0	0	2	3	0	0	0	0	0	0	0	2
		0	0	1	0	0	1	0	0	2	2	1	1	2	0	1	1	0	0	2
32	26/02/93	0	0	0	0	0	0	0	0	12	10	3	1	1	0	0	0	0	0	4
		0	0	0	0	0	1	0	0	0	4	1	0	0	0	0	0	0		3
		0	0	0	0	0	0	0	0	5	3	3	1	1	0	0	0	0	0	1
33	26/02/93	0	0	0	0	0	0	0	2	3	1	3	0	1	1	1	0	0	0	2
		0	0	0	0	0	0	0	0	4	2	1	1	1	0	1	0	0	0	1
		0	0	1	0	0	0	0	0	1	4	1	0	0	1	3	1	0	0	4
34	25/02/93	0	0	0	0	0	0	1	0	3	2	1	0	0	0	3	0	0	0	0
		0	0	0	0	0	0	0	0	2	1	0	0	3	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	0	0	0	0

Table B3 (Cont'd). River Taff Winter Baseline Survey Raw Data

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
18	16/03/93	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	6	0
		2	0	0	0	0	0	1	0	1	1	2	0	0	1	2	1	0
19	16/03/93	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0
		0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	4	0
		1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
20	16/03/93	4	0	4	1	0	0	0	0	0	0	2	1	0	0	0	9	0
		5	0	2	1	0	0	0	0	0	0	0	0	0	0	0	9	0
		2	0	0	0	0	0	0	0	0	0	1	0	0	0	1	3	0
21	16/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	16/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		2	0	2	0	0	1	0	0	0	0	2	0	0	0	3	2	0
23	16/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		0	0	1	0	0	0	0	0	0	0	2	0	0	0	2	2	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
24	16/03/93	1	0	0	0	0	0	0	0	0	1	2	0	0	0	1	0	0
		2	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
25	16/03/93	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
26	16/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	1	0
27	26/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	26/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
29	26/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
30	26/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
31	26/02/93	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	4	0
		0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	3	0
		2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
32	26/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0
		1	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
33	26/02/93	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	25/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Table B3 (Cont'd). River Taff Winter Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
35	25/02/93	6	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	25/02/93	9	3	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		11	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		8	3	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
37	18/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	18/03/93	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	18/03/93	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	18/03/93	8	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		5	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
41	18/03/93	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		5	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	28/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	28/02/93	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	28/02/93	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	28/02/93	3	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	28/02/93	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	28/02/93	16	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	28/02/93	8	3	1	0	0	0	1	0	2	3	0	0	0	0	0	0	0	1	0
		8	2	3	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0
		9	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
49	28/02/93	8	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	28/02/93	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		16	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B3 (Cont'd). River Taff Winter Baseline Survey Raw Data

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
35	25/02/93	0	0	1	0	0	0	0	0	1	2	1	0	0	0	1	0	0	0	2
		0	0	3	0	0	1	0	0	3	1	1	1	2	0	0	0	0	0	4
		0	0	0	0	1	0	0	0	2	0	0	1	0	0	0	0	0	0	0
36	25/02/93	0	0	1	0	0	0	0	0	6	4	2	0	3	0	1	0	0	0	5
		0	0	0	0	0	0	0	0	5	7	2	2	3	0	3	0	0	0	3
		0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	1
37	18/03/93	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0
		0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	1	0	0	1	0	0	0	2	0	0	0	0	0	0
38	18/03/93	0	0	0	0	0	0	0	0	1	4	3	0	0	0	0	0	0	0	0
		0	0	1	0	0	1	2	0	2	2	1	0	0	0	0	0	0	0	0
		0	0	2	0	0	0	1	0	2	0	3	0	3	0	0	0	0	0	0
39	18/03/93	0	0	9	0	0	0	0	4	1	1	0	1	19	1	1	0	0	0	0
		0	0	3	0	0	0	0	2	2	1	1	0	8	2	0	0	0	0	0
		0	0	2	0	1	0	0	1	0	0	1	0	7	2	2	1	0	0	1
40	18/03/93	0	0	1	0	0	0	1	0	1	2	0	1	3	0	0	0	0	0	0
		0	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	0	0
		0	0	3	0	0	0	0	3	0	2	1	1	5	0	1	0	0	0	0
41	18/03/93	0	0	1	0	0	0	0	2	0	1	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	3	7	10	2	2	2	0	0	0	0	0	1
		0	0	1	0	0	0	0	0	2	4	0	0	0	0	0	0	0	0	3
42	28/02/93	0	0	0	0	0	0	0	0	1	1	0	1	6	0	4	0	0	0	0
		0	0	0	0	0	0	0	0	2	0	0	0	5	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	2	0	0	1	2	1	1	0	0	0	0
42	28/02/93	0	0	1	0	0	0	1	0	3	4	1	2	2	0	2	0	0	0	2
		0	0	2	0	0	3	3	2	1	2	2	0	8	1	0	0	0	0	0
		0	0	2	0	0	2	1	0	1	3	2	2	3	0	2	1	0	0	0
44	28/02/93	0	0	0	0	0	0	3	0	3	1	3	0	2	0	0	0	0	0	3
		0	0	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	2	1	2	1	1	0	0	0	0	0	0	0	1
45	28/02/93	0	0	3	0	0	0	2	0	0	1	1	1	3	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	0	1	0	1
		0	0	0	1	0	0	0	1	3	3	0	0	2	0	0	0	1	0	2
46	28/02/93	0	0	0	1	0	0	0	1	3	1	1	0	1	0	1	1	1	0	0
		0	0	1	0	0	0	0	0	4	4	6	0	2	0	2	0	0	0	0
		0	0	0	0	0	0	0	1	2	3	0	1	4	0	0	0	0	0	3
47	28/02/93	0	0	0	0	0	0	0	0	1	3	3	1	0	1	0	0	0	0	3
		0	0	1	0	0	0	0	0	1	2	5	2	1	0	0	0	0	0	1
		0	0	5	0	0	0	0	1	0	2	0	1	3	0	0	0	0	0	0
48	28/02/93	0	0	11	2	1	0	0	3	5	7	13	7	13	4	1	6	1	0	6
		0	0	5	0	0	0	0	2	6	12	5	3	8	0	1	0	0	0	3
		0	0	3	1	0	2	0	1	4	11	7	2	12	1	0	1	0	0	6
49	28/02/93	0	0	0	0	0	0	0	0	5	2	1	0	2	0	2	1	0	0	2
		0	0	0	0	0	0	0	0	1	1	1	0	2	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	7	6	8	0	0	1	1	0	0	0	2
50	28/02/93	0	0	1	0	1	0	2	6	3	6	2	5	4	0	5	2	2	0	5
		0	0	1	0	0	0	0	2	5	5	3	4	1	0	3	0	0	0	4
		0	0	0	0	0	0	0	1	8	8	7	12	12	1	4	0	0	0	12

Table B3 (Cont'd). River Taff Winter Baseline Survey Raw Data

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
35	25/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	25/02/93	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	18/03/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	18/03/93	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	18/03/93	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
		1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0
40	18/03/93	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
41	18/03/93	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
42	28/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	28/02/93	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	12	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
		1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
44	28/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	28/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
46	28/02/93	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	28/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
48	28/02/93	2	0	1	0	1	0	1	0	0	1	0	0	0	0	2	5	1
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0
		0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	3	0
49	28/02/93	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
50	28/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Table B4. River East Lyn Site Location and Physical Characteristics

River	Site	Town	Grid Ref.	Land Use	Road Network	Access	Profile	Bank	Width	Depth	Pattern	Vegetation	Fly-tipping	Sewage
East Lyn	Lynmouth	Lynmouth	SS 724 495	1	2	1	4	3	5	5	2	4	0	0
East Lyn	Lynmouth	Lynmouth	SS 727 493	4	3	0	3	1	4	1	2	3	0	0
East Lyn	West Wood	Lynmouth	SS 736 487	4	0	0	3	1	4	2	2	3	0	0
East Lyn	d/s Watersmeet	Lynmouth	SS 745 487	4	0	0	2	1	4	2	2	3	0	0
Farley Water	u/s Watersmeet	Lynmouth	SS 744 486	3	0	0	3	1	4	2	2	2	0	0
Farley Water	Nr. Hillsford Br.	Lynmouth	SS 741 477	3	3	1	1	1	3	2	2	2	0	0
Farley Water	Nr Keepers Gate	Lynmouth	SS 742 474	4	3	1	1	1	3	1	2	2	0	0
East Lyn	Rockford	Brendon	SS 757 476	4	2	1	3	1	4	1	2	2	0	1
East Lyn	Hall Farm	Brendon	SS 778 482	4	0	0	3	1	4	1	2	2	0	0
East Lyn	Ashton Cleave	Brendon	SS 789 485	4	2	1	3	1	4	1	2	2	0	0
Badgworthy Water	Malmsmead	Brendon	SS 793 487	4	3	1	1	1	3	2	2	2	0	0
Badgworthy Water	d/s Cloud Farm	Brendon	SS794 475	4	0	0	1	1	3	2	3	3	0	0
Badgworthy Water	Badgwor. Wood	Brendon	SS 795 461	4	0	0	1	1	4	1	2	3	0	0
Badgworthy Water	Trib of B.W.	Brendon	SS 991 467	4	0	0	1	1	2	1	3	4	0	0
Oare Water	Oare Mead Fm.	Oare	SS 799 684	4	0	0	1	1	2	1	2	3	0	0
Oare Water	Oare	Oare	SS 803 486	4	3	0	1	1	2	1	3	2	0	0
Oare Water	d/s Oareford	Oare	SS 809 477	4	3	1	1	1	2	1	3	1	0	0
Chalk Water	Oareford	Oare	SS 815 476	4	0	0	1	1	2	1	2	1	0	1
Weir Water	Robbers Bridge	Oareford	SS 820 475	4	3	1	1	1	2	1	3	1	0	0
Weir Water	u/s Car Park	Oare	SS 826 477	4	0	0	1	1	1	1	3	1	0	0

Table B5. River E. Lyn Summer Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
7	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	28/07/92	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B5 (Cont'd). River E. Lyn Summer Baseline Survey Raw Data

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
2	28/07/92	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	28/07/92	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
4	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	28/07/92	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
7	28/07/92	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	28/07/92	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0
9	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
16	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B5 (Cont'd). River E. Lyn Summer Baseline Survey Raw Data

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	28/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
16	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B5 (Cont'd). River E. Lyn Summer Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
18	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
18	29/07/92	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
18	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	29/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B6. River E. Lyn Winter Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Table B6 (Cont'd). River E. Lyn Winter Baseline Survey Raw Data

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
2	10/02/93	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
3	10/02/93	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	10/02/93	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
6	10/02/93	0	0	1	0	0	0	1	0	2	0	0	1	2	0	3	1	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
7	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	3	0	3	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
10	10/02/93	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
		0	0	0	0	0	0	0	4	1	0	0	0	0	2	0	1	1	0	0
		0	0	0	0	0	0	0	5	0	0	0	1	0	0	0	0	0	0	0
11	11/02/93	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	11/02/93	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
13	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
14	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	11/02/93	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0
		0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
		0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0

Table B6 (Cont'd). River E. Lyn Winter Baseline Survey Raw Data

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
7	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
9	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	10/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
16	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B6 (Cont'd). River E. Lyn Winter Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
18	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
18	11/02/93	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
18	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	11/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B7. River Avill Site Location and Physical Characteristics

River	Site	Town	Grid Ref.	Land Use	Road Network	Access	Profile	Bank	Width	Depth	Pattern	Vegetation	Fly-tipping	Sewage
Avill	1:Dunster Beach	Dunster	SS 996 455	4	3	0	4	1	4	1	3	3	0	0
Avill	2:Marsh Bridge	Dunster	SS 995 445	1	2	0	3	1	4	1	3	2	0	0
Avill	3:Loxhole Bridge	Dunster	SS 996 438	4	3	1	2	2	4	2	2	2	0	0
Avill	4:Gallox Bridge	Dunster	SS 989 435	8	3	1	3	3	4	2	2	2	0	1
Avill	5:Avill Farm	Dunster	SS 983 434	4	2	0	3	1	3	1	2	1	0	0
Avill	6:Black Bell	Dunster	SS 980 427	4	3	1	1	1	1	1	2	1	0	0
Avill(Trib)	7:Crown Estate	Dunster	SS 980 423	4	3	0	1	1	2	1	2	1	0	0
Avill(Trib)	8:Croyden Hill	Dunster	SS 979 425	4	1	1	1	1	1	1	2	2	0	0
Avill	9:Nr. Kitswall Farm	Dunster	SS 973 429	4	2	0	2	1	4	2	2	2	0	0
Avill	10:Duddings	Timberscombe	SS 959 427	4	2	0	2	1	4	2	2	3	0	0
Avill	11:Timber. Bridge	Timberscombe	SS 956 426	4	3	1	2	1	4	2	2	2	0	0
Avill	12:Bickham Farm	Timberscombe	SS 952 421	4	2	1	2	1	4	2	2	2	0	0
Avill	13:Pitt Bridge	Timberscombe	SS 944 413	4	2	1	2	3	3	2	3	2	0	0
Avill	14:Nr. Sully Farm	Timberscombe	SS 944 396	4	0	0	1	1	1	1	2	1	0	0
Avill	15:Nr. Sully Farm	Timberscombe	SS 944 395	4	0	0	1	1	2	1	2	1	0	0
Avill	16:Steart	Wheddon Cross	SS 937 403	4	3	1	1	1	2	1	2	1	0	0
Avill	17:Hawkwell Wood	Wheddon Cross	SS 923 397	4	3	1	1	1	3	1	2	2	0	0
Avill	18:Nr. Kennels	Timberscombe	SS 952 429	4	3	1	1	1	3	2	2	2	0	0
Avill	19:Ranscombe Fm.	Timberscombe	SS 949 437	4	3	0	1	1	3	1	2	1	0	0
Avill	20:Wooton Courtenay	Timberscombe	SS 937 436	4	3	1	1	3	2	1	2	2	0	0

Table B8. River Avill Summer Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B8 (Cont'd). River Avill Summer Baseline Survey Raw Data

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	21/07/92	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
2	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	21/07/92	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
7	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
8	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1
10	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
13	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B8 (Cont'd). River Avill Summer Baseline Survey Raw Data

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1	21/07/92	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	21/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	22/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B8 (Cont'd). River Avill Summer Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
18	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
18	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
18	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	23/07/92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B9. River Avill Winter Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B9 (Cont'd). River Avill Winter Baseline Survey Raw Data

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
2	07/02/93	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
3	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/02/93	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	07/02/93	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0
10	07/02/93	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	08/02/93	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B9 (Cont'd). River Avill Winter Baseline Survey Raw Data

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	07/02/93	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	07/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B9 (Cont'd). River Avill Winter Baseline Survey Raw Data

Site	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
18	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Date	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
18	08/02/93	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	08/02/93	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	08/02/93	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site	Date	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
18	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	08/02/93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C

List of Abbreviations

Survey Form Abbreviations

Access	Site Access
Brown TOT	Brown Goods Total
ClotShoe	Cloth/Shoe
Com TOT	Combustible Total
FemTOT	Feminine Hygiene Total
GenSwTOT	General Sewage Total
GlasTOT	Glass Total
GRANDTOT	Total for 14 Litter Groups
Land-use	Site Land-use
MetTOT	Metal Total
MiGenTOT	Miscellaneous General Total
MiTrTOT	Miscellaneous Transport Total
MotTOT	Motor Vehicles Total
NonCTOT	Non-combustible Total
PackTOT	Packaging Total
PantyLin	Panty Liners
PlasBag	Plastic Bag
PlasTOT	Plastic Total
RoadNet	Site Road Network
SanTowel	Sanitary Towels
Sewage	Sewage Pipe
SweetPap	Sweet Papers
TextTOT	Textiles Total
TOTBUILD	Total Building/DIY Related
TOTGEN	Total General
TOTHCI	Total Household/Commercial/Industrial
TOTTRAN	Total Transport Associated
Veg	Vegetation
WhiteTOT	White Goods Total
<30She	Plastic Sheeting < 30 cm
30-60She	Plastic Sheeting 30-60 cm
>60She	Plastic Sheeting > 60 cm

Statistical Abbreviations

Abs	Absolute
ANOVA	Analysis of Variance
Cum	Cumulative
Deg Fre	Degrees of Freedom
F-stat	F-statistic
K-S	Kolmogorov-Smirnov
Signif	Significance
Std Dev	Standard Deviation
Std Err	Standard Error

RIVER TAFF

Paired T-Tests for Summer/Winter Comparison

Paired T-Test for Summer FemTOT and Winter FemTOT

	Cases	Mean	Std Dev	Std Err
Summer FemTOT	50	19	17.839	2.5228
Winter FemTOT	50	18.68	15.601	2.206
Difference	50	0.32	15.613	2.2080

t-statistic = 0.145
degrees of freedom = 49
2-tail probability = 0.885

Paired T-Test for Summer GenSwTOT and Winter GenSwTOT

	Cases	Mean	Std Dev	Std Err
Summer GenSwTOT	50	1.4	2.899	0.410
Winter GenSwTOT	50	0.98	1.491	0.211
Difference	50	0.42	2.990	0.423

t-statistic = 0.993
degrees of freedom = 49
2-tail probability = 0.326

Paired T-Test for Summer ComTOT and WinterComTOT

	Cases	Mean	Std Dev	Std Err
Summer ComTOT	50	3.04	3.928	0.555
Winter ComTOT	50	0.561	0.109	0.157
Difference	50	2.48	3.887	0.550

t-statistic = 4.511
degrees of freedom = 49
2-tail probability = 0.000

Paired T-Test for Summer NonCTOT and Winter NonCTOT

	Cases	Mean	Std Dev	Std Err
Summer NonCTOT	50	1.42	2.186	0.309
Winter NonCTOT	50	1	1.702	0.241
Difference	50	0.42	2.417	0.342

t-statistic = 1.229
degrees of freedom = 49
2-tail probability = 0.225

Paired T-Test for Summer BrownTOT and Winter BrownTOT

	Cases	Mean	Std Dev	Std Err
Summer BrownTOT	50	0.06	0.240	0.004
Winter BrownTOT	50	0.1	0.364	0.050
Difference	50	-0.04	0.283	0.040

t-statistic = -1
degrees of freedom = 49
2-tail probability = 0.322

Paired T-Test for Summer WhiteTOT and Winter WhiteTOT

	Cases	Mean	Std Dev	Std Err
Summer WhiteTOT	50	0	0	0
Winter WhiteTOT	50	0.04	0.198	0.028
Difference	50	-0.04	0.198	0.028

t-statistic = -1.429
degrees of freedom = 49
2-tail probability = 0.159

Paired T-Test for Summer MetTOT and Winter MetTOT

	Cases	Mean	Std Dev	Std Err
Summer MetTOT	50	5.98	7.303	1.033
Winter MetTOT	50	5.82	5.910	0.836
Difference	50	0.16	5.184	0.733

t-statistic = 0.218
degrees of freedom = 49
2-tail probability = 0.828

Paired T-Test for Summer PlasTOT and Winter PlasTOT

	Cases	Mean	Std Dev	Std Err
Summer PlasTOT	50	45.78	30.634	4.332
Winter PlasTOT	50	37.16	25.247	3.570
Difference	50	8.62	25.317	3.580

t-statistic = 2.408
degrees of freedom = 49
2-tail probability = 0.02

Paired T-Test for Summer GlassTOT and Winter GlassTOT

	Cases	Mean	Std Dev	Std Err
Summer GlassTOT	50	2.9	3.86	0.547
Winter GlassTOT	50	1.06	2.567	0.363
Difference	50	1.84	2.831	0.400

t-statistic = 4.596
degrees of freedom = 49
2-tail probability = 0.000

Paired T-Test for Summer TexTOT and Winter TexTOT

	Cases	Mean	Std Dev	Std Err
Summer TexTOT	50	5.9	6.418	0.908
Winter TexTOT	50	8.14	8.526	1.206
Difference	50	-2.24	6.103	0.863

t-statistic = -2.595
degrees of freedom = 49
2-tail probability = 0.012

Paired T-Test for Summer MotTOT and Winter MotTOT

	Cases	Mean	Std Dev	Std Err
Summer MotTOT	50	1.68	1.942	0.275
Winter MotTOT	50	0.86	1.552	0.219
Difference	50	0.82	1.815	0.257

t-statistic = 3.195
degrees of freedom = 49
2-tail probability = 0.002

Paired T-Test for Summer MiTrTOT and Winter MiTrTOT

	Cases	Mean	Std Dev	Std Err
Summer MiTrTOT	50	0.32	0.653	0.092
Winter MiTrTOT	50	0.24	0.591	0.084
Difference	50	0.08	0.900	0.127

t-statistic = 0.629
degrees of freedom = 49
2-tail probability = 0.533

Paired T-Test for Summer PackTOT and Winter PackTOT

	Cases	Mean	Std Dev	Std Err
Summer PackTOT	50	1.82	2.007	0.284
Winter PackTOT	50	1.16	1.888	0.267
Difference	50	.66	1.858	0.263

t-statistic = 2.511
degrees of freedom = 49
2-tail probability = 0.015

Paired T-Test for Summer MiGenTOT and Winter MiGenTOT

	Cases	Mean	Std Dev	Std Err
Summer MiGenTOT	50	3.28	3.226	0.456
Winter MiGenTOT	50	5.36	5.540	0.783
Difference	50	-2.08	4.907	0.694

t-statistic = -2.998
degrees of freedom = 49
2-tail probability = 0.004

Paired T-Test for Summer GRANDTOT and Winter GRANDTOT

	Cases	Mean	Std Dev	Std Err
Summer GRANDTOT	50	91.22	57.408	8.119
Winter GRANDTOT	50	80.24	52.854	7.475
Difference	50	10.98	41.862	5.920

t-statistic = 1.855
degrees of freedom = 49
2-tail probability = 0.070

Analysis of Variance of Litter Types by Land-use

ANOVA for TOTHCI by Land-use

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Land-use	43095.736	7	6156.534	5.644	0.0000
Error	100349.574	92	1090.756		
Total	143445.310	99	1448.943		

Table of Means for TOTHCI by Land-use

Land-use	No	Mean	Std Dev	Std Err
1	20	49.50	25.9666	5.806
2	2	45.00	24.0416	17.000
4	22	35.64	22.7273	4.8455
5	10	93.60	50.7744	16.0563
7	10	98.20	35.6614	11.2771
8	20	51.35	37.3508	8.3519
9	10	48.80	36.7871	11.6331
10	6	56.67	23.5768	9.6252

Homogeneity of Variance Tests for TOTHCI by Land-use

Bartlett-Box F-test = 1.745; P = 0.0945
Cochran's C (max var / sum var) = 0.289; P = 0.025
Hartley's F (max var / min var) = 4.991

Multiple Range Tests for TOTHCI by Land-use

Land-use	Cases	Mean	4	2	9	1	8	10	5	7
4	22	35.64							*	*
2	2	45.0								
9	10	48.8								
1	20	49.5								
8	20	51.35								
10	6	56.67								
5	10	93.6	*							
7	10	98.2	*							

Method: 95% Scheffe interval.
Table Ranges: 5.44 5.44 5.44 5.44 5.44 5.44 5.44
* denotes significantly different pairs.

One Sample Kolmogorov-Smirnov Test on TOTHCI: Normal

	Maximum Difference (abs)	K-S Statistic	2-tail Probability
Land-use1	0.2463895	1.101887	0.1763
Land-use4	0.1131024	0.5304972	0.9410
Land-use5	0.1594921	0.5043583	0.9611
Land-use7	0.1687086	0.5335035	0.9384
Land-use8	0.1752071	0.7835499	0.5711
Land-use9	0.2322997	0.734596	0.6531
Land-use10	0.2451185	0.6004153	0.8637

ANOVA for TOTHCI by RoadNet.

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Road Net.	10347.403	2	5173.702	3.771	0.0265
Error	133097.907	97	1372.143		
Total	143445.310	99	1448.943		

Table of Means for TOTHCI by RoadNet.

Road Net.	No	Mean	Std Dev	Std Err
1	46	67.1304	42.3900	6.2501
2	14	42.1429	23.3760	6.2475
3	40	48.9750	34.0185	5.3788

Homogeneity of Variance Tests for TOTHCI by RoadNet.

Bartlett-Box F-test = 3.189; P = 0.041
Cochran's C (max var / sum var) = 0.513; P = 0.017
Hartley's F (max var / min var) = 3.288

One Sample Kolmogorov-Smirnov Test on TOTHCI: Normal

	Maximum Difference (abs)	K-S Statistic	2-tail Probability
RoadNet1	0.1454855	0.9867308	0.2845
RoadNet2	0.152146	0.5692782	0.9022
RoadNet3	0.1453903	0.9195288	0.3663

ANOVA for TOTHCI by Access

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Access	0.560	1	0.560	0.000	0.9845
Error	143444.750	98	1463.722		
Total	143445.310	99	1448.943		

ANOVA for TOTBUILD by Land-use

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Land-use	185.499	7	26.500	1.415	0.2089
Error	1723.491	92	18.734		
Total	1908.990	99	19.283		

ANOVA for TOTBUILD by RoadNet.

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
RoadNet.	51.675	2	25.837	1.349	0.2642
Error	1857.315	97	19.148		
Total	1908.990	99	19.283		

ANOVA for TOTBUILD by Access

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Access	0.004	1	0.004	0.000	0.9888
Error	1908.986	98	19.479		
Total	1908.990	99	19.283		

ANOVA for TOTTRAN by Land-use

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Land-use	76.594	7	10.942	2.977	0.0074
Error	338.156	92	3.676		
Total	414.750	99	4.189		

Table of Means for TOTTRAN by Land-use

Land-use	No	Mean	Std Dev	Std Err
9	10	0.50	0.9718	0.3073
8	20	1.45	1.3169	0.2945
4	22	0.82	1.2203	0.2602
7	10	3.80	3.9101	1.2365
1	20	1.50	2.1151	0.4730
5	10	2.00	1.6997	0.5375
10	6	1.83	1.7224	0.7032
2	2	2.00	1.4142	1.0000

Homogeneity of Variance Tests for TOTTRAN by Land Use

Bartlett-Box F-test = 4.416; P = 0.0001
Cochran's C (max var / sum var) = 0.481; P = 0.000
Hartley's F (max var / min var) = 16.188

Multiple Range Tests for TOTTRAN by Land-use

Land-use	Cases	Mean	9	4	8	1	10	2	5	7
9	10	.5								*
4	22	0.818								*
8	20	1.45								
1	20	1.5								
10	6	1.812								
2	2	2								
5	10	2								
7	10	3.8	*	*						

Method: 95% Scheffe interval.
Table Ranges: 5.44 5.44 5.44 5.44 5.44 5.44 5.44
* denotes significantly different pairs.

One Sample Kolmogorov-Smirnov Test on TOTTRAN: Normal

	Maximum Difference (abs)	K-S Statistic	2-tail Probability
Land-use1	0.2608947	1.166757	0.1314
Land-use4	0.3396286	1.592999	0.0125
Land-use5	0.3218508	1.017782	0.2514
Land-use7	0.2344354	0.7413499	0.6417
Land-use8	0.2337166	1.045212	0.2246
Land-use9	0.3965473	1.253993	0.0861
Land-use10	0.2509077	0.6145959	0.8444

Kruskal-Wallis One-Way ANOVA: TOTTRAN by Land-use

Land-use	Cases	Rank Sum	Mean Rank
1	20	964.5	48.225
2	2	135	67.5
4	22	888	40.364
5	10	630.5	63.05
7	10	640	64
8	20	1105	55.25
9	10	339	33.9
10	6	348	58
Total	100	5050	50.5

correction for ties = 8.815E-02
chi-square statistic = 12.878
degrees of freedom = 7
right-tail probability = 0.0751

ANOVA for TOTTRAN by RoadNet.

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
RoadNet.	11.484	2	5.742	1.381	0.2562
Error	403.266	97	4.157		
Total	414.750	99	4.189		

ANOVA for TOTTRAN by Access

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Access	2.865	1	2.865	0.682	0.4110
Error	411.885	98	4.203		
Total	414.750	99	4.189		

ANOVA for TOTGEN by Land-use

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Land-use	687.307	7	98.187	4.143	0.0005
Error	2180.083	92	23.697		
Total	2867.390	99	28.964		

Table of Means for TOTGEN by Land-use

Land-use	No	Mean	Std Dev	Std Err
9	10	7.1000	6.2263	1.9689
8	20	5.1000	4.399761	0.9838
4	22	3.5000	3.7891	0.8078
7	10	12.6000	7.7201	2.4413
1	20	4.3500	3.4224	0.7653
5	10	7.2000	5.5737	1.7626
10	6	6.6667	4.8028	1.9607
2	2	3.0000	2.8284	2.0000

Homogeneity of Variance Tests for TOTGEN by Land-use

Bartlett-Box F-test = 1.840; P = 0.076
Cochran's C (max var / sum var) = 0.2894; P = 0.025
Hartley's F (max var / min var) = 7.45

Multiple Range Tests for TOTGEN by Land-use

Land-use	Cases	Mean	2	4	1	8	10	9	5	7
2	2	3								
4	22	3.5								*
1	20	4.35								*
8	20	5.1								*
10	6	6.667								
9	10	7.1								
5	10	7.2								
7	10	12.6		*	*	*				

Method: 95% Scheffe interval.
Table Ranges: 5.44 5.44 5.44 5.44 5.44 5.44 5.44
* denotes significantly different pairs.

One Sample Kolmogorov-Smirnov Test on TOTGEN: Normal

	Maximum Difference (Abs)	K-S Statistic	2-tail Probability
Land-use1	0.1746849	0.7812148	0.5750
Land-use4	0.1993557	0.9350609	0.3462
Land-use5	0.2534706	0.8015445	0.5416
Land-use7	0.1375511	0.4349746	0.9915
Land-use8	0.1689593	0.7556088	0.6177
Land-use9	0.1907189	0.603106	0.8601
Land-use10	0.2774016	0.6794924	0.7450

ANOVA for TOTGEN by RoadNet.

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
RoadNet.	241.222	2	120.611	4.455	0.0141
Error	2626.168	97	27.074		
Total	2867.390	99	28.964		

Table of Means for TOTGEN by RoadNet.

RoadNet.	No	Mean	Std Dev	Std Err
1	46	7.4783	5.5647	0.8205
2	14	4.8571	3.8201	1.0210
3	40	4.2250	5.1714	0.8177

Homogeneity of Variance Tests for TOTGEN by RoadNet.

Bartlett-Box F-test = 1.216; P = 0.297
Cochran's C (max var / sum var) = 0.428; P = 0.255
Hartley's F (max var / min var) = 2.122

Multiple Range Tests for TOTGEN by RoadNet.

RoadNet.	Cases	Mean	3	2	1
3	40	4.225			*
2	14	4.857143			
1	46	7.478261	*		

Method: 95% Scheffe interval.
Table Ranges: 3.52 3.52
* denotes significantly different pairs.

One Sample Kolmogorov-Smirnov Test on TOTGEN: Normal

	Maximum Difference (abs)	K-S Statistic	2-tail Probability
RoadNet1	0.1699624	1.152741	0.1402
RoadNet2	0.1993704	0.7459757	0.6339
RoadNet3	0.2186257	1.38271	0.0437

ANOVA for TOTGEN by Access

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	24.711	1	24.711	0.852	0.3583
Error	2842.679	98	29.007		
Total	2867.390	99	28.964		

Analysis of Variance for Litter Types by Vegetation

ANOVA for SanTowel by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	753.484	2	376.742	3.369	0.0386
Error	10624.281	95	111.835		
Total	11377.765	97	117.297		

Table of Means for SanTowel by Veg

Veg	No	Mean	Std Dev	Std Err
2	34	16.0882	12.7074	2.1793
3	46	12.3478	8.9523	1.3199
4	18	8.2222	9.9679	2.3495

Homogeneity of Variance Tests for SanTowel by Veg

Bartlett-Box F-test = 2.410; P = 0.089
Cochran's C (max var / sum var) = 0.474; P = 0.073
Hartley's F (max var / min var) = 2.015

Multiple Range Tests for SanTowel by Veg

Group	Cases	Mean	4	3	2
4	18	8.222222			*
3	46	12.34783			
2	34	16.08824	*		

Method: 95% Scheffe interval.
Table Ranges: 3.52 3.52
* denotes significantly different pairs.

One Sample Kolmogorov-Smirnov Test on SanTowel: Normal

Veg	Maximum Difference (abs)	K-S Statistic	2-tail Probability
2	0.1240889	0.7235566	0.6717
3	0.1023063	0.6938751	0.7214
4	0.2751754	1.16747	0.1309

ANOVA for PantyLin by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	108.710	2	54.355	2.647	0.0761
Error	1950.566	95	20.532		
Total	2059.276	97	21.230		

ANOVA for Tampon by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	28.688	2	14.344	2.935	0.0579
Error	464.221	95	4.887		
Total	492.908	97	5.082		

ANOVA for <30She by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	74.846	2	37.423	1.662	0.1952
Error	2138.919	95	22.515		
Total	2213.765	97	22.822		

ANOVA for 30-60She by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	265.936	2	132.968	2.965	0.0563
Error	4260.187	95	44.844		
Total	4526.122	97	46.661		

ANOVA for >60She by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	417.135	2	208.568	4.806	0.0103
Error	4123.038	95	43.400		
Total	4540.173	97	46.806		

Table of Means for >60She by Veg

Veg	No	Mean	Std Dev	Std Err
2	34	9.5294	8.5218	1.4615
3	46	6.6087	5.0967	0.7515
4	18	3.7222	5.7272	1.3499

Homogeneity of Variance Tests for >60She by Veg

Bartlett-Box F-test = 5.366; P = 0.005
Cochran's C (max var / sum var) = 0.553; P = 0.004
Hartley's F (max var / min var) = 2.796

Multiple Range Tests for >60She by Veg

Veg	Cases	Mean	4	3	2
4	18	3.722222			*
3	46	6.608696			
2	34	9.529411	*		

Kruskal-Wallis One-Way ANOVA: >60She by Veg

Veg	Cases	Rank Sum	Mean Rank
3	46	2315.5	50.33696
2	34	2034	59.82353
4	18	501.5	27.86111
Total	98	4851	49.5

correction for ties = 5.208831E-03
chi-square statistic = 15.025
degrees of freedom = 2
right-tail probability = 0.0005

ANOVA for PlasBag by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	38.021	2	19.011	1.062	0.3498
Error	1700.438	95	17.899		
Total	1738.459	97	17.922		

ANOVA for SweetPap by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	54.630	2	27.315	0.325	0.7230
Error	7972.972	95	83.926		
Total	8027.602	97	82.759		

ANOVA for ClotShoe by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	181.561	2	90.781	2.319	0.1039
Error	3718.970	95	39.147		
Total	3900.531	97	40.212		

T-Test of Sewage-Derived Totals Split According to Presence or Absence of Sewage Pipe

F-test for FemTOT split by Sewage

	Cases	Mean	Std Dev	Std Err	F-stat
Sewage = 0	72	15.847	13.865	1.634	2.29
Sewage = 1	28	26.535	20.701	3.912	
Total	100	18.84	16.042	1.604	

degrees of freedom: numerator = 27; denominator = 71
right-tail probability = 0.0038

Separate Variance T-Test for FemTOT split by Sewage

t-statistic = -2.521
degrees of freedom = 36.816
2-tail probability = 0.0162
Difference between means = -10.688
95% confidence interval = -17.929 to -3.448

F-test for GenSwTOT split by Sewage

	Cases	Mean	Std Dev	Std Err	F-stat
Sewage = 0	72	1.138	2.393	0.282	1.309
Sewage = 1	28	1.321	2.091	0.395	
Total	100	1.19	2.314	0.231	

degrees of freedom: numerator = 27; denominator = 71
right-tail probability = 0.2199

Pooled Variance T-Test for GenSwTOT split by Sewage

t-statistic = -0.3542
degrees of freedom = 98
2-tail probability = 0.7239
Difference between means = -0.1825
95% confidence interval = -1.205 to 0.840

F-test for SEWTOT split by Sewage

	Cases	Mean	Std Dev	Std Err	F-stat
Sewage = 0	72	16.986	14.67	1.73	2.286
Sewage = 1	28	27.857	22.19	4.19	
Total	100	20.03	17.07	1.71	

degrees of freedom: numerator = 27; denominator = 71
right-tail probability = 0.0029

Separate Variance T-Test for SEWTOT split by Sewage

t-statistic = -2.396
degrees of freedom = 36.57
2-tail probability = 0.0218
Difference between means = -10.871
95% confidence interval = -18.582 to -3.160

Principal Components Factoring for Combined Summer/Winter 14 Group Totals

Variance Table for Combined Summer/Winter 14 Group Totals

Factor	Eigenvalue	%	Cum %
1	4.729	33.8%	33.8%
2	1.887	13.5%	47.3%
3	1.424	10.2%	57.4%

Factor Loading Matrix for Combined Summer/Winter 14 Group Totals

Group	Factor 1	Factor 2	Factor 3
FemTOT	0.4528	-0.2953	-0.4019
GenSwTOT	0.4626	-0.4014	0.2008
ComTOT	0.4502	0.0798	0.5723
NonCTOT	0.7142	0.2690	0.2242
BrownTOT	0.5931	-0.4079	0.0494
WhiteTOT	0.4349	-0.2283	-0.4072
MetTOT	0.6621	0.4865	0.0484
PlasTOT	0.7351	-0.2578	-0.1906
GlassTOT	0.6543	-0.3960	0.3611
TexTOT	0.7324	0.0261	-0.5374
MotTOT	0.4947	0.6154	0.1778
MiTrTOT	0.3009	0.4720	0.0906
PackTOT	0.6905	-0.2396	0.1276
MiGenTOT	0.5496	0.4712	-0.4454

Rotated Factor Loading Matrix of Varimax Rotation for Combined Summer/Winter 14 Group Totals

Group	Factor 1	Factor 2	Factor 3
FemTOT	0.0236	-0.0029	0.9000
GenSwTOT	0.4807	-03591	0.5413
ComTOT	0.5267	0.3794	0.0640
NonCTOT	0.5279	0.6230	-0.065
BrownTOT	0.7126	-0.0284	0.0388
WhiteTOT	0.3005	-0.0187	0.0139
MetTOT	0.1951	0.7753	0.1795
PlasTOT	0.4747	0.2079	0.6642
GlassTOT	0.8287	0.0640	0.1893
TexTOT	0.1163	0.3758	0.5938
MotTOT	0.0722	0.8085	0.0992
MiTrTOT	0.0231	0.5642	-0.0549
PackTOT	0.6532	0.1883	0.2302
MiGenTOT	-0.1084	0.6437	0.2216

Factor Scores of Varimax Rotation Combined Summer/Winter Surveys

	Summer Survey			Winter Survey		
Site	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
1	-0.0614	-0.7896	-0.9857	-0.5650	-0.3595	-0.9282
2	-0.3981	-0.0215	-1.0554	-0.0727	-0.3307	-1.0518
3	-0.3490	-0.8275	-1.1402	-0.4466	-0.6418	-1.0629
4	-0.3422	-0.8335	-1.2172	-0.3345	-0.7909	-1.1733
5	-0.0655	-0.4783	-1.0210	-0.0569	-0.2502	-1.1383
6	0.5913	-0.3436	-0.5607	0.2262	-0.0897	-0.1678
7	-0.2915	-0.3711	0.0965	-0.1550	-0.4035	0.1597
8	-0.0028	-0.2616	-0.4711	-0.6701	0.0376	-0.0101
9	-0.4443	-0.8127	0.3979	-0.5472	-0.7488	0.9193
10	-0.8709	0.2310	1.7438	-1.3063	2.4887	1.2474
11	0.5148	1.4677	-0.5302	-0.6122	0.0524	-0.2899
12	-0.5999	-0.1472	0.4322	-0.5837	-0.1645	-0.0024
13	0.5941	0.5347	0.0097	-0.4776	0.6611	-1.3039
14	-0.3847	1.4290	-0.4389	-0.7236	-0.0689	-0.1170
15	-0.0250	0.7886	3.7314	-0.8954	1.2767	0.6618
16	5.3330	-0.7518	1.6028	5.0817	-1.5372	-0.4676
17	-0.1592	-0.2613	-0.1986	-0.8880	-0.2972	0.9064
18	1.4847	0.0256	-0.4756	-0.3815	0.5045	1.2854
19	0.5276	-0.3384	1.4116	-0.5222	-0.2603	0.9586
20	-0.4384	4.6351	0.2268	-1.1734	3.7802	0.3941
21	-0.6125	-0.0548	0.4612	-0.7213	-0.7647	0.4852
22	0.2410	-0.1435	1.7059	-0.6257	1.2393	0.0651
23	0.8638	-0.1527	1.2604	-0.3990	0.0057	-0.3704
24	1.0028	0.0693	2.3873	1.4933	-0.0096	-0.3151
25	0.0503	-0.6554	0.1366	-0.4520	-0.3911	0.7218
26	1.0403	1.7813	-1.0076	0.3976	-0.2076	-0.7064
27	-0.3345	-0.7909	-1.1733	-0.3275	-0.8362	-1.1636
28	-0.0938	-0.4295	-1.0609	-0.3150	-0.5434	-1.1775
29	-0.2094	-0.5415	-0.4036	-0.5870	-0.9263	0.1899
30	0.1177	-0.3280	-0.7020	-0.4636	-0.1668	-0.1295
31	-0.1449	1.2537	-0.6540	-0.1151	1.6961	-0.6211
32	-0.3957	-1.1813	2.7780	-0.9431	-0.2905	1.2975
33	-0.0812	-1.1291	0.6560	-0.4088	-1.2425	2.0803
34	0.3993	-0.6866	1.2934	-0.5109	-0.8065	0.4490
35	0.8795	0.0702	-0.4452	-0.6407	-0.4271	0.0081
36	-0.2238	-0.2811	-0.9503	-0.5451	-0.9524	1.2455
37	-0.1444	1.0336	-1.5002	-0.4223	-0.6010	-1.1156
38	0.0698	0.1995	-0.8846	-0.2278	-0.4122	-0.8215
39	-0.3054	-0.7189	-0.4946	-0.2215	0.5083	-0.4464
40	-0.2659	-0.4448	0.3535	-0.1090	-0.8245	0.1467
41	2.1331	1.2311	-0.2581	-0.3812	-0.8192	0.1145
42	0.2523	-0.4613	-1.0169	-0.4048	-0.7002	-0.8599
43	0.3579	0.8425	0.0767	-1.1730	0.9393	-0.1677

Factor Scores of Varimax Rotation (Cont'd)

	Summer Survey			Winter Survey		
Site	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 1**	**Factor 2**	**Factor 3**
44	0.2931	0.0866	-0.8096	-0.6206	-0.3420	-0.7485
45	0.4250	-0.3865	-0.5598	-0.1930	-0.4671	-0.5955
46	2.4624	2.5133	-1.0483	-0.2691	-0.4350	-0.4253
47	0.1017	-0.0252	-0.1891	-0.8029	-0.6289	0.4713
48	1.5442	1.3280	0.0457	1.4483	1.7058	1.4252
49	-0.0423	-0.4392	0.1286	-0.7008	-0.3959	0.3237
50	0.6680	0.4627	0.0748	-0.4461	-0.6568	2.0623

Principal Components Factoring for Summer 14 Group Totals

Variance Table of Summer 13 Group Totals

Factor	Eigenvalue	%	Cum %
1	4.431429	34.1%	34.1%
2	1.914894	14.7%	48.8%
3	1.495795	11.5%	60.3%

Factor Loading Matrix of Summer 13 Group Totals

Group	Factor 1	Factor 2	Factor 3
FemTOT	0.4665	-0.3871	-0.6217
GenSwTOT	0.5790	-0.5817	0.2921
ComTOT	0.4616	0.1878	0.1600
NonCTOT	0.6285	0.4724	0.2803
BrownTOT	0.4741	-0.2597	0.5389
MetTOT	0.6807	0.3756	-0.0116
PlasTOT	0.7089	-0.2967	-0.2057
GlassTOT	0.6245	-0.3149	0.3981
TexTOT	0.7048	-0.1833	-0.4685
MotTOT	0.5302	0.5593	-0.1538
MiTrTOT	0.2820	0.5131	0.2335
PackTOT	0.6425	-0.2023	0.1318
MiGenTOT	0.6478	0.3492	-0.3369

Rotated Factor Loading Matrix for Varimax Rotation of Summer 13 Group Totals

Group	Factor 1	Factor 2	Factor 3
FemTOT	-0.0604	0.0655	0.8636
GenSwTOT	-0.1067	0.8110	0.2792
ComTOT	0.2109	0.0958	0.0434
NonCTOT	0.7002	0.2671	-0.0708
BrownTOT	0.1364	0.7822	-0.0846
MetTOT	0.7234	0.2286	0.2180
PlasTOT	0.0816	0.3514	0.6303
GlassTOT	0.1404	0.7780	0.1222
TexTOT	0.3192	0.2634	0.7903
MotTOT	0.7416	-0.0678	0.1855
MiTrTOT	0.6089	0.0846	-0.2262
PackTOT	0.2356	0.5695	0.2980
MiGenTOT	0.6987	0.0404	0.4643

Factor Scores for Varimax Rotation of Summer 13 Group Totals

Site	Factor 1	Factor 2	Factor 3
1	-0.732	-0.185	-0.917
2	0.046	-0.381	-0.998
3	-0.728	-0.388	-1.019
4	-0.724	-0.389	-1.107
5	-0.500	-0.359	-0.725
6	-0.533	-0.133	-0.465
7	-0.398	-0.267	-0.141
8	-0.415	-0.380	-0.442
9	-0.711	-0.372	0.465
10	0.276	-0.572	2.216
11	1.787	-0.080	0.395
12	-0.273	-0.636	0.222
13	0.578	0.129	0.391
14	1.497	-0.932	0.396
15	0.157	-0.446	3.336
16	-0.533	5.705	-0.320
17	-0.162	-0.052	-0.231
18	0.479	1.764	-0.586
19	-0.086	0.479	1.983
20	4.284	-0.694	0.794
21	-0.224	-0.745	0.353
22	-0.485	-0.151	1.847
23	-0.526	0.317	0.845
24	0.003	1.438	2.130
25	-0.824	-0.231	0.006

Factor Scores for Varimax Rotation Summer of 13 Group Totals (Cont'd)

Site	Factor 1	Factor 2	Factor 3
26	1.662	0.586	-1.448
27	-0.702	-0.385	-1.073
28	-0.547	-0.442	-0.905
29	-0.606	-0.413	-0.384
30	-0.286	-0.117	-0.560
31	0.950	-0.798	-0.272
32	-1.446	0.144	1.858
33	-1.077	0.054	0.318
34	-1.379	-0.349	0.686
35	0.146	0.441	-0.291
36	-0.214	-0.547	-0.682
37	1.238	-0.493	-1.145
38	0.179	-0.417	-0.508
39	-0.815	-0.464	-0.527
40	-0.725	-0.513	0.215
41	-0.276	-0.466	-0.333
42	-0.529	-0.219	-0.772
43	0.419	-0.320	0.021
44	0.268	0.006	-0.349
45	-0.256	0.330	-0.747
46	1.740	0.100	-0.756
47	-0.180	-0.102	-0.047
48	1.657	1.726	-0.089
49	-0.730	-0.383	-0.113
50	0.255	0.601	-0.526

Principal Components Factoring for Winter 14 Group Totals

Variance Table for Winter 14 Group Totals

Factor	Eigenvalue	%	Cum %
1	5.6706	40.5%	40.5%
2	2.1907	15.6%	56.2%
3	1.5096	10.8%	66.9%

Factor Matrix for Winter 14 Group Totals

Group	Factor 1	Factor 2	Factor 3
FemTOT	0.4461	-0.1413	0.7779
GenSwTOT	0.2687	0.0613	0.7249
ComTOT	0.6725	0.0555	-0.1327
NonCTOT	0.8239	0.0870	-0.2633
BrownTOT	0.7228	-0.5169	-0.1981
WhiteTOT	0.6308	-0.3318	-0.0790
MetTOT	0.6534	0.5360	-0.1860
PlasTOT	0.7630	-0.2132	0.2263
GlassTOT	0.7399	-0.5151	-0.1497
TexTOT	0.8074	0.1694	0.1923
MotTOT	0.4473	0.7251	-0.1474
MiTrTOT	0.2719	0.4583	0.2379
PackTOT	0.7279	-0.2848	-0.1385
MiGenTot	0.5793	0.5792	-0.0626

Rotated Factor Matrix of Varimax Rotation for Winter Survey

Group	Factor 1	Factor 2	Factor 3
FemTOT	0.2464	0.0112	0.8736
GenSwTOT	0.0062	0.0935	0.7698
ComTOT	0.5397	0.4222	0.0586
NonCTOT	0.6752	0.5470	-0.0253
BrownTOT	0.9100	-0.0205	0.0199
WhiteTOT	0.7059	0.0689	0.1053
MetTOT	0.2736	0.8209	-0.0063
PlasTOT	0.6729	0.1960	0.4333
GlassTOT	0.9109	-0.0166	0.0710
TexTOT	0.5066	0.5440	0.4062
MotTOT	-0.0044	0.8641	-0.0299
MiTrTOT	-0.0915	0.4945	0.2960
PackTOT	0.7723	0.1680	0.0744
MiGenTOT	0.1607	0.8005	0.0909

Factor Scores of Varimax Rotation for Winter Survey

Site	Factor 1	Factor 2	Factor 3
1	-0.4024	-0.3167	-1.0237
2	-0.2139	-0.3974	-0.7366
3	-0.4118	-0.6015	-1.0344
4	-0.4175	-0.7452	-1.0765
5	0.0743	-0.1667	-1.2271
6	0.8618	-0.0537	-0.3560
7	0.0664	-0.2485	0.0802
8	-0.1390	0.1541	-0.4664
9	-0.0040	-0.7326	0.6420
10	-1.1355	2.4771	2.4442
11	-0.5958	0.0836	0.2556
12	-0.2236	-0.0643	-0.2397
13	-0.6842	0.5085	-0.6086
14	-0.4493	0.1140	-0.2991
15	1.1329	1.8201	0.9116
16	5.7143	-1.1521	0.1101
17	-0.1841	-0.1845	0.4185
18	-0.0069	0.6183	1.7142
19	0.2908	-0.2059	0.4376
20	0.0920	4.1121	-1.2126
21	-0.3838	-0.6640	0.5336
22	-0.0283	1.3468	-0.2627
23	-0.0326	0.1136	-0.7597
24	1.9581	0.0617	-0.6315
25	-0.1453	-0.2214	0.6456
26	0.1109	-0.1633	-0.5847
27	-0.4105	-0.7942	-1.0539
28	-0.3240	-0.5253	-1.1219
29	-0.3061	-0.9075	0.1684
30	-0.2538	-0.1064	-0.1827
31	-0.1865	2.0497	-0.6740
32	-0.4844	-0.0826	1.4982
33	-0.6721	-1.0076	3.3406
34	-0.5204	-0.6470	0.9939
35	-0.5105	-0.2993	0.0420
36	-0.3526	-0.8109	1.6361
37	-0.4261	-0.5517	-1.0912
38	-0.1784	-0.3867	-0.8984
39	-0.1544	0.4713	-0.5449
40	-0.3555	-0.7160	0.6680
41	-0.2395	-0.7473	0.1867
42	-0.3323	-0.6741	-0.8698
43	-0.3968	1.0113	-0.8124

Factor Scores of Varimax Rotation for Winter Survey (Cont'd)

Site	Factor 1	Factor 2	Factor 3
44	-0.3841	-0.2715	-0.9017
45	-0.1396	-0.4212	-0.5777
46	-0.0871	-0.4289	-0.3954
47	-0.3783	-0.5782	0.3447
48	1.9913	1.9309	1.1222
49	-0.3277	-0.3477	0.1049
50	0.5859	-0.6513	1.3447

RIVER E. LYN

Paired T-Tests for Summer/Winter Comparison

Paired T-Test for Summer FemTOT and Winter FemTOT

	Cases	Mean	Std Dev	Std Err
Summer FemTOT	20	0.05	0.2236	0.05
Winter FemTOT	20	0	0	
Difference	20	0.05	0.2236	0.05

t-statistic = 1
degrees of freedom = 19
2-tail probability = 0.3299

Paired T-Test for Summer GenSwTOT and Winter GenSwTOT

	Cases	Mean	Std Dev	Std Err
Summer GenSwTOT	20	0.1	0.3078	0.0689
Winter GenSwTOT	20	0	0	0
Difference	20	0.1	0.3078	0.0689

t-statistic = 1.453
degrees of freedom = 19
2-tail probability = 0.1626

Paired T-Test for Summer ComTOT and WinterComTOT

	Cases	Mean	Std Dev	Std Err
Summer ComTOT	20	0.05	0.2236	0.05
Winter ComTOT	20	0	0	
Difference	20	0.05	0.2236	0.05

t-statistic = 1
degrees of freedom = 19
2-tail probability = 0.3299

Paired T-Test for Summer NonCTOT and Winter NonCTOT

	Cases	Mean	Std Dev	Std Err
Summer NonCTOT	20	00		
Winter NonCTOT	20	0.1	0.3078	0.0688
Difference	20	-0.1	0.3078	0.0688

t-statistic = -1.453
degrees of freedom = 19
2-tail probability = 0.1626

Paired T-Test for Summer WhiteTOT and Winter WhiteTOT

Test cannot be performed

Paired T-Test for Summer WhiteTOT and Winter WhiteTOT

Test cannot be performed

Paired T-Test for Summer MetTOT and Winter MetTOT

	Cases	Mean	Std Dev	Std Err
Summer MetTOT	20	0.1	0.4472	0.1
Winter MetTOT	20	0.35	0.7452	0.1666
Difference	20	-0.25	0.9105	0.2035

t-statistic = -1.228
degrees of freedom = 19
2-tail probability = 0.2345

Paired T-Test for Summer PlasTOT and Winter PlasTOT

	Cases	Mean	Std Dev	Std Err
Summer PlasTOT	20	1.6	2.8359	0.6341
Winter PlasTOT	20	3.55	4.2485	0.95
Difference	20	-1.95	4.8933	1.0942

t-statistic = -1.782
degrees of freedom = 19
2-tail probability = 0.0907

Paired T-Test for Summer GlassTOT and Winter GlassTOT

	Cases	Mean	Std Dev	Std Err
Summer GlassTOT	20	0.15	0.4893	0.1094
Winter GlassTOT	20	0.3	0.6569	0.1469
Difference	20	-0.15	0.5871	0.1313

t-statistic = -1.1425
degrees of freedom = 19
2-tail probability = 0.2674

Paired T-Test for Summer TexTOT and Winter TexTOT

	Cases	Mean	Std Dev	Std Err
Summer TexTOT	20	0	0	0
Winter TexTOT	20	0.05	0.2236	0.05
Difference	20	-0.05	0.2236	0.05

t-statistic = -1
degrees of freedom = 19
2-tail probability = 0.3299

Paired T-Test for Summer MotTOT and Winter MotTOT

Test cannot be performed

Paired T-Test for Summer MiTrTOT and Winter MiTrTOT

Test cannot be performed

Paired T-Test for Summer PackTOT and Winter PackTOT

	Cases	Mean	Std Dev	Std Err
Summer PackTOT	20	0	0	0
Winter PackTOT	20	0.1	0.4472	0.1
Difference	20	-0.1	0.4472	0.1

t-statistic = -1
degrees of freedom = 19
2-tail probability = 0.3299

Paired T-Test for Summer MiGenTOT and Winter MiGenTOT

	Cases	Mean	Std Dev	Std Err
Summer MiGenTOT	20	0.05	0.2236	0.05
Winter MiGenTOT	20	0.8	1.151	0.2575
Difference	20	-0.75	1.0699	0.2392

t-statistic = -3.1349
degrees of freedom = 19
2-tail probability = 0.0055

Paired T-Test for Summer GRANDTOT and Winter GRANDTOT

	Cases	Mean	Std Dev	Std Err
Summer GRANDTOT	20	2.1	3.2428	0.7251
Winter GRANDTOT	20	5.25	6.0773	1.3589
Difference	20	-3.15	6.2515	1.3988

t-statistic = -2.253
degrees of freedom = 19
2-tail probability = 0.0362

Analysis of Variance for Litter Types by Vegetation

ANOVA for <30She by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	3.608	3	1.203	1.953	0.1385
Error	22.167	36	0.616		
Total	25.775	39	0.661		

Kruskal-Wallis One-Way ANOVA: <30She by Veg

	Cases	Rank Sum	Mean Rank
4	4	50	12.5
3	12	250	20.833
2	16	386	24.125
1	8	134	16.75
Total	40	820	20.5

correction for ties = 0.2331
chi-square statistic = 5.535
degrees of freedom = 3
right-tail probability = 0.1366

ANOVA for 30-60She by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	1.671	3	0.557	0.768	0.5195
Error	26.104	36	0.725		
Total	27.775	39	0.712		

Kruskal-Wallis One-Way ANOVA: 30-60She by Veg

Veg	Cases	Rank Sum	Mean Rank
4	4	62	15.5
3	12	270.5	22.542
2	16	328.5	20.531
1	8	159	19.875
Total	40	820	20.5

correction for ties = 0.424015
chi-square statistic = 1.94571
degrees of freedom = 3
right-tail probability = 0.5838

ANOVA for >60She by Veg

Due to	Sum of Squares	Deg Fre	Mean Square	F-stat	Signif
Veg	0.313	3	0.104	0.923	0.4395
Error	4.063	36	0.113		
Total	4.375	39	0.112		

Kruskal-Wallis One-Way ANOVA: >60She by Veg

Veg	Cases	Rank Sum	Mean Rank
4	4	72	18
3	12	276	23
2	16	308	19.25
1	8	164	20.5
Total	40	820	20.5

correction for ties = 0.6717
chi-square statistic = 2.786
degrees of freedom = 3
right-tail probability = 0.4259

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Paired T-Tests for Summer/Winter Comparison

Paired T-Test for Summer FemTOT and Winter FemTOT

Test cannot be performed

Paired T-Test for Summer GenSwTOT and Winter GenSwTOT

Test cannot be performed

Paired T-Test for Summer ComTOT and Winter ComTOT

Test cannot be performed

Paired T-Test for Summer NonCTOT and Winter NonCTOT

	Cases	Mean	Std Dev	Std Err
Summer NonCTOT	20	0	0	0
Winter NonCTOT	20	0.05	0.2236	0.05
Difference	20	-0.05	0.2236	0.05

t-statistic = -1
degrees of freedom = 19
2-tail probability = 0.3299

Paired T-Test for Summer BrownTOT and Winter BrownCTOT

Test cannot be performed

Paired T-Test for Summer WhiteTOT and Winter WhiteTOT

Test cannot be performed

Paired T-Test for Summer MetTOT and Winter MetTOT

	Cases	Mean	Std Dev	Std Err
Summer MetTOT	20	0.05	0.2236	0.05
Winter MetTOT	20	0.05	0.2236	0.05
Difference	20	0	0.3244	0.0773

t-statistic = 0
degrees of freedom = 19
2-tail probability = 1.0000

Paired T-Test for Summer PlasTOT and Winter PlasTOT

	Cases	Mean	Std Dev	Std Err
Summer PlasTOT	20	0.85	1.3089	0.2926
Winter PlasTOT	20	1.45	1.9595	0.4381
Difference	20	-0.6	2.1126	0.4724

t-statistic = -1.270
degrees of freedom = 19
2-tail probability = 0.2194

Paired T-Test for Summer GlassTOT and Winter GlassTOT

Test cannot be performed

Paired T-Test for Summer TexTOT and Winter TexTOT

	Cases	Mean	Std Dev	Std Err
Summer TexTOT	20	0.05	0.2236	0.05
Winter TexTOT	20	0.05	0.2236	0.05
Difference	20	0	.3244	0.0725

t-statistic = 0
degrees of freedom = 19
2-tail probability = 1.0000

Paired T-Test for Summer MotTOT and Winter MotTOT

	Cases	Mean	Std Dev	Std Err
Summer MotTOT	20	0	0	0
Winter MotTOT	20	0.05	0.2236	0.05
Difference	20	-0.05	0.2236	0.05

t-statistic = -1
degrees of freedom = 19
2-tail probability = 0.3299

Paired T-Test for Summer MiTrTOT and Winter MiTrTOT

Test cannot be performed

Paired T-Test for Summer PackTOT and Winter PackTOT

	Cases	Mean	Std Dev	Std Err
Summer PackTOT	20	0.05	0.2236	0.05
Winter PackTOT	20	0	0	0
Difference	20	0.05	0.2236	0.05

t-statistic = 1
degrees of freedom = 19
2-tail probability = 0.3299

Paired T-Test for Summer MiGenTOT and Winter MiGenTOT

	Cases	Mean	Std Dev	Std Err
Summer MotTOT	20	0.05	0.2236	0.05
Winter MotTOT	20	0.1	0.3078	0.0688
Difference	20	-0.05	0.3940	0.0881

t-statistic = -0.5675
degrees of freedom = 19
2-tail probability = 0.5770

Paired T-Test for Summer GRANDTOT and Winter GRANDTOT

	Cases	Mean	Std Dev	Std Err
Summer GRANDTOT	20	1.1	1.7137	0.3832
Winter GRANDTOT	20	1.8	2.4623	0.5506
Difference	20	-0.7	2.2501	0.5031

t-statistic = -1.3912
degrees of freedom = 19
2-tail probability = 0.1802